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Research Article

A new ant species of the genus *Carebara* Westwood, 1840 (Hymenoptera, Formicidae, Myrmicinae) with a key to Chinese species

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Abstract

A new Chinese ant species *Carebara laeviceps* **sp. nov.** is described based on the major and minor workers. This species is most similar to *C. lusciosa* (Wheeler, 1928) due to a spineless propodeum, the absence of horns, and a smooth head capsule. It is distinguished by the following features: (1) antenna 10-segmented; (2) katepisternum rugose-reticulate; (3) in major workers, lateral sides of head in full-face view parallel; (4) metanotal groove distinct, anterodorsal corner forming an acute tooth behind metanotal groove. Moreover, an updated key to Chinese *Carebara* species is presented based on major workers, with a checklist comprising a total of 36 Chinese *Carebara* species and subspecies. Morphological structures and scanning electron micrographs of the newly discovered species' minor and major workers are provided.

Key words: *Carebara laeviceps*, China, East Asia, new species, Sichuan Province, taxonomy

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Introduction

The genus *Carebara* Westwood, 1840 is a large genus of ants that contains 234 valid species (including 9 fossil species) and 22 subspecies (Bolton 2023). It is a worldwide genus mainly recorded in the tropical and subtropical regions (Bharti and Kumar 2013; Azorsa and Fisher 2018). They nest in soil or termite mounds, and some species also inhabit rotten wood (Bharti and Kumar 2013). Most members of *Carebara* are minute in size and subterranean, mainly feeding on dead insects and other invertebrates. Some species are aggressive ground predators with mass raiding habits (Moffett 1988), like those of the former genus *Pheidologeton* Mayr, 1862. Studies regarding the ethology and life cycle of *Carebara* are still limited.

The genus was established based on the type species *C. lignata* Westwood, 1840. It was originally incorporated into the formerly valid subfamily Attidae after its establishment (Smith 1858). Later, the taxonomic status underwent

several changes among the tribes Solenopsidini (Forel 1893; Emery 1895; Wheeler 1910, 1922; Kusnezov 1964) Pheidologetini (Emery 1913, 1914, 1924; Bolton 1994), and the *Pheidologeton* genus group (Ettershank 1966; Bolton 1987) due to the incomplete records for different castes and polymorphism. The genus *Carebara* was considered as a senior synonym of the genera *Aeromyrma* Forel, *Afroxyidris* Belshaw & Bolton, *Amauromyrmex* Wheeler, *Aneleus* Emery, *Crateropsis* Patrizi, *Erebomyrma* Wheeler, *Hendecatella* Wheeler, *Idrisella* Santschi, *Lecanomyrma* Forel, *Neoblepharidatta* Sheela & Narendran, *Nimbamyrma* Bernard, *Oligomyrmex* Mayr, *Paedalgus* Forel, *Parvimyrma* Eguchi & Bui, *Pheidologeton* Mayr, *Solenops* Karavaiev, *Spelaeomyrmex* Wheeler, and *Sporocleptes* Arnold (Fischer et al. 2014), and finally placed in Crematogastrini by Ward et al. (2015) based on a comprehensive phylogenetic analysis of 11 genes.

Taxonomic changes at the genus level have superseded some early regional revisions of *Carebara* species. Moreover, the lack of a comprehensive revision, especially for Old World species, has created difficulties in species identification (Fischer et al. 2015). To address these issues, recent regional studies have been conducted in India (Bharti and Kumar 2013; Bharti et al. 2014; Akbar and Bharti 2017), Saudi Arabia (Sharaf and Aldawood 2013), the Afrotropical region (Fischer et al. 2014, 2015), Brazil (Baccaro et al. 2015), Madagascar (Azorsa and Fisher 2018), and Australia (Heterick 2021). The studies about species groups initially concentrated on New World species, and Fernández (2004, 2010) reviewed American species and proposed five species groups based on the morphology of worker caste. In the Old World, the species groups of *Carebara* were first studied by Bharti and Kumar (2013). They placed 11 Indian species into three groups and recommended the fusion of the *C. concinna* group with the *lignata* group based on the eyeless minor worker of *C. asina* (Forel, 1902). Fischer et al. (2014) established the *C. polita* group, which shares morphological similarities with *Pheidologeton*, and included six Afrotropical species and two Neotropical species. This study also synonymized *Pheidologeton* with *Carebara*. Later, Fischer et al. (2015) established the *phragmotica* group, and the *acutispina* group was proposed by Hosoishi et al. (2022), both including phragmotic species.

In China, *C. castanea* Smith, 1858 was the first Chinese *Carebara* species to be described from Hong Kong. Subsequently, *C. sauteri* (Forel, 1912) and *C. yanoi* (Forel, 1912), followed by the queen caste-established species *C. amia* (Forel, 1913), were all collected in Taiwan. Wheeler (1921) described a species from Zhejiang, namely *C. vespillo* (Wheeler, 1921). Later, Wheeler (1928) described three new species and two new subspecies of China; among them, *Oligomyrmex silvestrii taiponicus* was raised to species status by Bolton (1995) and is now known under the name *C. taiponica* (Wheeler, 1928). Another species *Oligomyrmex silvestrii* was considered a secondary homonym of *Aneleus silvestrii* Santschi, 1914, later renamed *Oligomyrmex wheeleri* Ettershank, 1966, but now known as *C. wheeleri* (Ettershank, 1966). The remaining three taxa are *C. lusciosa*, *C. polyphemus* (Wheeler, 1928), and *C. capreola laeviceps* (Wheeler, 1928).

Later, Wu and Wang (1995) revised some ant genera from the Chinese mainland, including the former valid genera *Pheidologeton* and *Oligomyrmex* (now both in *Carebara*). They also described three new species, namely *C. hunanensis* (Wu & Wang, 1995), *C. jiangxiensis* (Wu & Wang, 1995), and *C. pseudolusciosa* (Wu & Wang, 1995). It is worth mentioning that Wu and Wang (1995) erroneously illus-

trated these three species in relation to eye position, tooth numbers, and cephalic indices (Xu 2003). Zhou and Zheng (1997) as well as Li and Tang (1986) conducted comprehensive studies on *Carebara* from Guangxi Province, and described four new species, *C. nanningensis* (Li & Tang, 1986), *C. latinoda* (Zhou & Zheng, 1997), *C. melasolena* (Zhou & Zheng, 1997), and *C. trechideros* (Zhou & Zheng, 1997).

The very first comprehensive revision of former *Oligomyrmex* species in China was presented by Xu (2003), who studied this genus in more depth, conducting a revision of 26 species in China, and described eight new species, namely *C. altinodus* (Xu, 2003), *C. curvispina* (Xu, 2003), *C. striata* (Xu, 2003), *C. acutispina* (Xu, 2003), *C. obtusidenta* (Xu, 2003), *C. bihornata* (Xu, 2003), *C. rectidorsa* (Xu, 2003) and *C. reticapita* (Xu, 2003) from China. Additionally, Xu excluded *C. cribriceps* (Wheeler, 1927). Despite Zhou's (2001) description of *C. cribriceps* in Guangxi, Zhou's illustration of this species displays a minor concavity in the posterior margin of the head, in contrast to Wheeler's (1927) account, which distinctly portrays a pronounced concavity in the posterior margin. This disparity suggests that the species documented by Zhou may be an undescribed species from China (Xu 2003). Later, a new and different species, *C. zengchengensis* (Zhou et al., 2006) was described from Guangdong.

Carebara species from Taiwan were mostly studied by Terayama (2009), who made several revisions and described two new species *C. qianliyan* Terayama, 2009 and *C. sakamotoi* Terayama et al., 2012. Currently, there are a total of 36 valid species and subspecies in China.

As a contribution to the taxonomy of the *Carebara* species of China, we report a new species: *C. laeviceps* sp. nov. High-resolution images and scanning electron micrographs (SEM) of the minor and major workers of the new species are provided. An updated key to Chinese *Carebara* species is also provided based on the major worker.

Material and methods

All samples were collected from Kaijiang County, Sichuan Province, China by direct sampling on the ground and preserved in 75% EtOH, then deposited in the Forest Insect Herbarium, Ant Specimen Branch of Southwest Forestry University, Kunming, China (**SWFU**). Specimens were observed under a Phenix XSP-02 microscope. Photographs were taken by Samsung SM-N9860, and SEM photographs were taken by a FEI Quanta 450 at 12.50 kV. To observe the microstructure and preserve the specimens, some of the specimens were disassembled before observation under SEM. The specimens were sputter-coated with gold for 30 min. Image stacking using Helicon Focus software. Morphological terminology and standard measurements mostly follow Bolton (1994), all measurements are given in millimeters:

HL Head Length. Maximum length from the mid-point of the anterior clypeal margin to the mid-point of the posterior margin measured in full-face view.

HW Head Width. Maximum width of the head measured in full-face view.

EL Eye Length. Maximum length of the eye measured in lateral view.

SL Scape Length. Maximum length of the antennal scape measured in full-face view.

WL Weber's Length. Maximum diagonal length from the most anterior point of the pronotal slope to the most posteroventral margin of propodeal lobe measured in lateral view.

PNW Pronotum Width. Maximum width of pronotum measured in dorsal view.

PNH Pronotum Height. Maximum height of pronotum measured in lateral view from index of procoxa to the highest point of the dorsal pronotum.

MNH Promesonotum Height. Maximum height of promesonotum measured in lateral view from the index of mesocoxa to the highest point of the dorsal pronotum.

PDH Propodeum Height. Maximum height of propodeum, measured in lateral view from the highest point of the dorsopropodeum perpendicular to a line that marks the lateroventral borders of the katepisternum and the propodeum.

PTL Petiolar Length. Maximum length of petiole measured in lateral view from most anteroventral point of the peduncle, at or below the propodeal lobe, to most posterodorsal point at the junction with helcial tergite.

PTH Petiolar Height. Maximum height of petiole measured in lateral view from the highest (median) point of the node, orthogonally to the ventral outline of the node.

PTW Petiolar Width. Maximum width of petiole measured in dorsal view.

PPL Postpetiolar Length. Maximum length of postpetiole measured in dorsal view from the anterior end of the node to the posterior end of the node.

PPH Postpetiolar Height. Maximum height of postpetiole measured in lateral view from the highest point of the node to the lowest point of the ventral process, often in an oblique line.

PPW Postpetiolar Width. Maximum width of postpetiole measured in dorsal view.

Ratios

CI Cephalic index: HW / HL × 100;

SI Scape index: SL / HW × 100;

EI Eye index: EL / HW × 100;

LPpI Lateral postpetiole index: PPL / PPH × 100;

DPpI Dorsal postpetiole index: PPW / PPL × 100;

PpWI Postpetiole width index: PPW / PTW × 100;

PpLI Postpetiole length index: PPL / PTL ×100;

PpHI Postpetiole height index: PPH / PTH × 100;

PPI Postpetiole index: PPW / PNW × 100.

Taxonomy

Genus *Carebara* Westwood, 1840

Carebara Westwood, 1840: 86. Type species: *Carebara lignata* Westwood, 1840: 86, Indonesia (Java). Indomalaya.

= *Pheidologeton* Mayr, 1862: 750. Synonymized by Fischer et al. 2014: 63.

= *Oligomyrmex* Mayr, 1867: 110. Synonymized by Fernández 2004: 194.

= *Aeromyrma* Forel, 1891: 198. Synonymized by Fernández 2004: 194.

= *Aneleus* Emery, 1900: 327. Synonymized by Fernández 2004: 194.
= *Erebomyrma* Wheeler, 1903: 138. Synonymized by Fernández 2004: 194.
= *Paedalgus* Forel, 1911: 217. Synonymized by Fernández 2004: 194.
= *Lecanomyrma* Forel, 1913: 56. Synonymized by Fernández 2004: 194.
= *Spelaeomyrmex* Wheeler, 1922: 9. Synonymized by Fernández 2004: 194.
= *Hendecatella* Wheeler, 1927: 93. Synonymized by Fernández 2004: 194.
= *Amauromyrmex* Wheeler, 1929: 1. Synonymized by Fischer et al. 2014: 63.
= *Solenops* Karavaiev, 1930: 207. Synonymized by Fernández 2004: 194.
= *Idrisella* Santschi, 1937: 372. Synonymized by Fischer et al. 2014: 66.
= *Crateropsis* Patrizi, 1948: 174. Synonymized by Fernández 2004: 194.
= *Sporocleptes* Arnold, 1948: 219. Synonymized by Fernández 2004: 194.
= *Nimbamyrma* Bernard, 1953: 240. Synonymized by Fernández 2004: 194.
= *Afroxyidris* Belshaw & Bolton, 1994: 631. Synonymized by Fernández 2004: 194.
= *Neoblepharidatta* Sheela & Narendran, 1997: 88. Synonymized by Fernández 2004: 194.
= *Parvimyrma* Eguchi & Bui, 2007: 40. Synonymized by Fernández 2010: 195.

Synopsis of members of Carebara from China. Currently, there are 36 *Carebara* species and subspecies in China, with the majority in the southern and southwestern regions (Fig. 1). The highest diversity is observed in Guangdong, Guangxi, Yunnan, and Sichuan provinces (Xu 2003; Zhou and Zheng 1997).

Here we provide a brief overview of the provisional definition of Chinese *Carebara* species groups. In addition to the former *Pheidologeton* species, other *Carebara* members in China (except *C. amia*) align with the *concinna-lignata* group proposed by Bharti. It is worth mentioning that the criteria for classification vary among different studies. Bharti and Kumar (2013) suggested merging the *concinna* and *lignata* groups, while Fischer et al. (2015) retained the *lignata* group, defining its features based on Fernández (2004): workers typically small with 9-segmented antenna, mandibles 3- or 4-toothed, absent eyes and propodeal teeth, and a rounded dorsum of the propodeum. The queens are generally much larger than the workers. Hosoishi et al. (2022) established the *acutispina* group; however, it is highly probable that this is an artificial group within the *concinna-lignata* group. Due to the lack of comprehensive revisions of all castes (especially queens and males), the current definition of species groups relies predominantly on the morphology of the worker caste. However, this approach introduces uncertainties due to the potential influence of convergent evolution and a global investigation into *Carebara* species, utilizing molecular data, is imperative for a more accurate understanding of the phylogenetic relationship between groups. To prevent the proposal of multiple species groups, our definition is mainly based on Bharti and Kumar (2013).

There are 11 species and subspecies of China belonging to the previously valid genus *Pheidologeton*: *C. affinis* (Jerdon, 1851), *C. diversa* (Jerdon, 1851), *C. diversa draco* (Santschi, 1920), *C. diversa laotina* (Santschi, 1920), *C. latinoda*, *C. melasolena*, *C. nanningensis*, *C. trechideros*, *C. vespillo*, *C. yanoi*, *C. zengchengensis*. These species are identified by their 11-segmented antennae, distinct polymorphic worker castes, and multifaceted eyes (Fischer et al. 2015). Fischer et al. (2014) indicated that former *Pheidologeton* species would be split into two groups: one with a polymorphic worker caste and the other with a dimorphic worker caste, and the 11 Chinese taxa mentioned above belong to the former group.

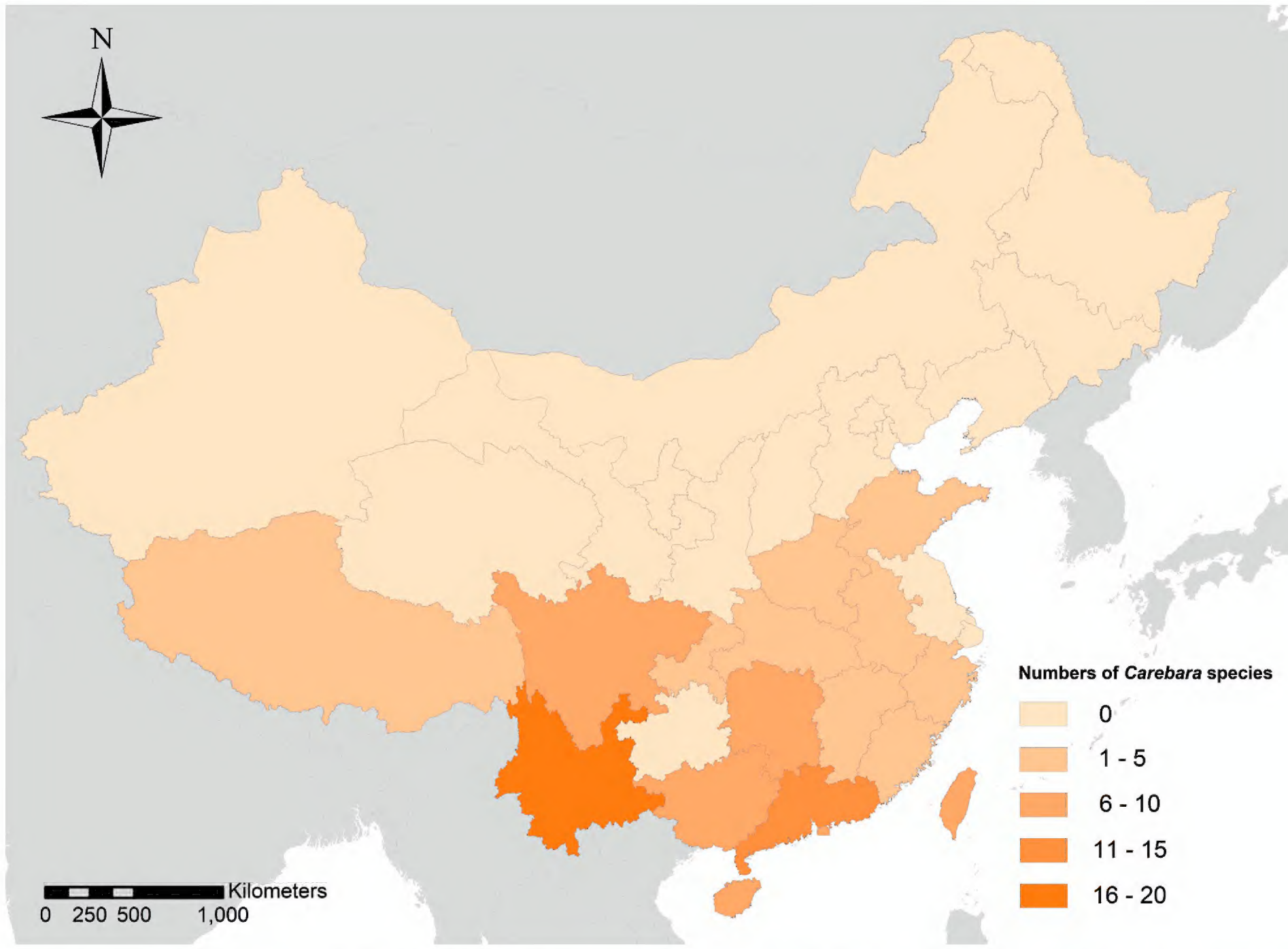

Figure 1. Map of the diversity of known Chinese *Carebara* species. Shades from pale to dark indicate species numbers from low to high.

The *lignata* group was originally established by Fernández (2004) to group New World species characterized by minor workers with 9-segmented antenna and the absence of eyes. The minor workers of this group mainly lack propodeal spines. Major workers present or absent. Members of the *concinna* group with dimorphic workers, eyes present in both major and minor workers, propodeum armed or only angulated, antenna 9- to 11- (rarely 8-) segmented. Bharti and Kumar (2013) suggested redefining the *concinna* group including the *lignata* group; this alteration was based on the observation that the major worker of *C. asina* aligned with the *concinna* group, whereas the minor worker lacked eyes and propodeal spines, consistent with the traditional *lignata* group proposed by Fernández (2010).

Certain Chinese *Carebara* species, like *C. bihornata* and *C. sakamotoi*, also form a bridge between the *lignata* and *concinna* groups. Similar to *C. asina*, *C. bihornata* exhibit eyeless minor workers with an unarmed propodeum, while the major workers accord with the features of *concinna* group. Some species provide additional insights into the *concinna-lignata* group, such as *C. capreola* and *C. curvispina*, both characterized by eyeless major and minor workers. This suggests that the features of the *concinna-lignata* group include: (1) workers monomorphic or dimorphic; (2) antenna 9- to 11- (rarely 8-) segmented; (3) propodeal spines present or absent in major and minor workers; (4) eyes present or absent in major and minor workers.

Key to *Carebara* species of China based on major worker caste

This key is based on Xu (2003) and Zhou et al. (2006), including 34 species and subspecies; some illustrations of the key were drawn from Xu (2003) and Terayama (1996). The following species are excluded from this key because descriptions of the major workers are unavailable: *C. amia*, *C. castanea*, and *C. lignata*. Some distribution data about Chinese *Carebara* species in previous studies are ambiguous. After verification with Xu (pers. comm. July 21, 2023), some records are not accepted in this study and the following species are excluded from the Chinese fauna: *C. asina*, *C. bengalensis* (Forel, 1902), *C. bruni* (Forel, 1913), *C. cribriceps* (Wheeler, 1927), and *C. pumilia* Fischer et al., 2014.

1 Antenna 11-segmented (Fig. 2A) **2**
– Antenna 9- or 10-segmented (Fig. 2B, C) **17**
2 Worker caste polymorphic, with continuous series of intermediates between minor and largest major worker **3**
– Worker caste dimorphic **13**

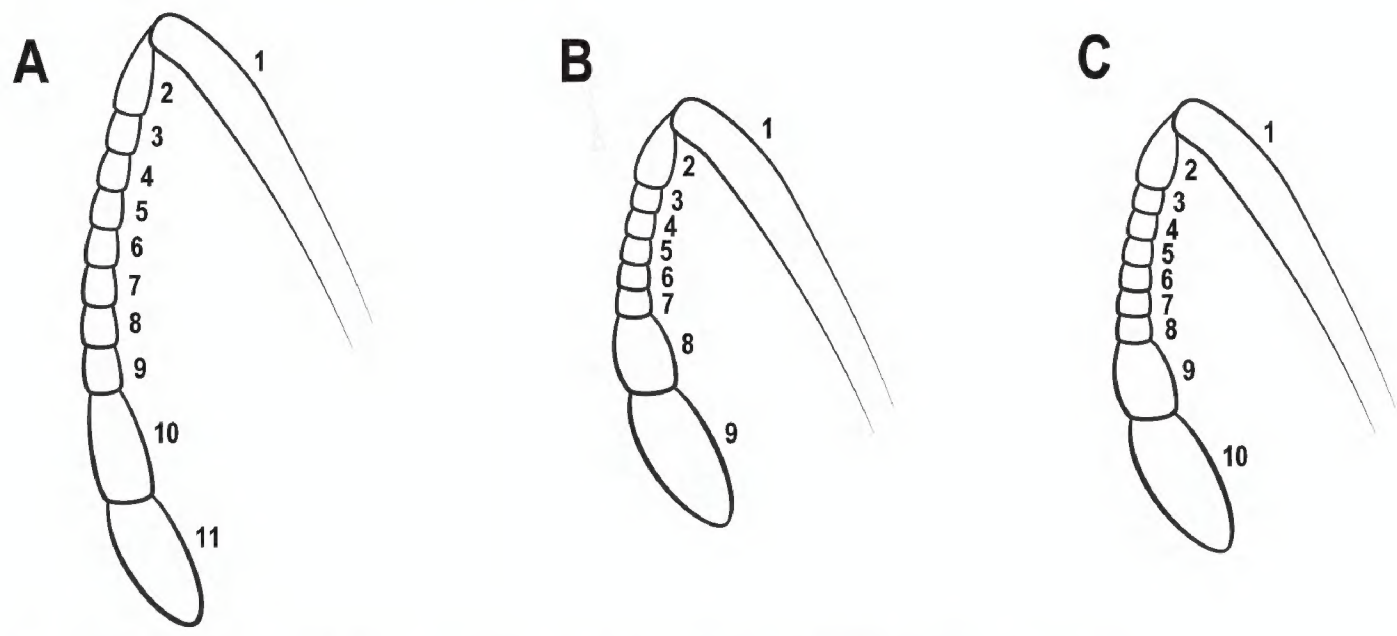

Figure 2. Antenna **A** 11-segmented **B** 9-segmented **C** 10-segmented.

3 Propodeal spines long, > 1/2 of the distance between the base of two spines (Fig. 3A) **4**
– Propodeal spines short, < 1/3 of the distance between the base of 2 spines (Fig. 3B) **9**

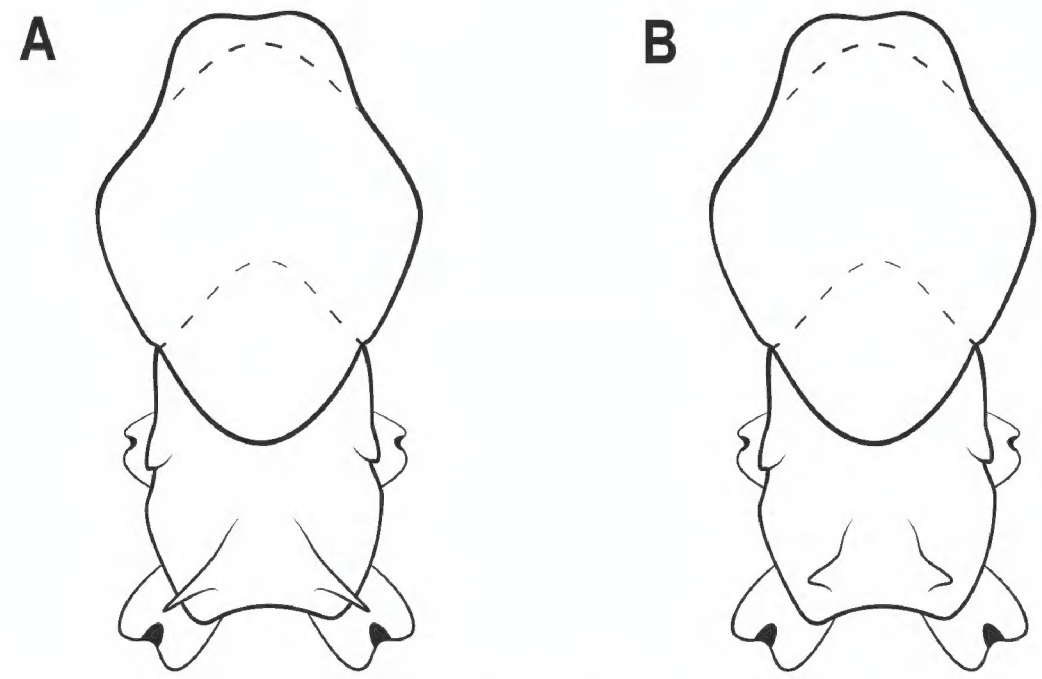

Figure 3. Mesosoma **A** longer spine **B** shorter spine.

4 Largest major worker with mesoscutellum strongly convex in lateral view and with single ocellus on the front of head (Fig. 4A, C) **5**

– Largest major worker with mesoscutellum broadly convex in lateral view and with no ocelli on the front of head (Fig. 4B, D) **7**

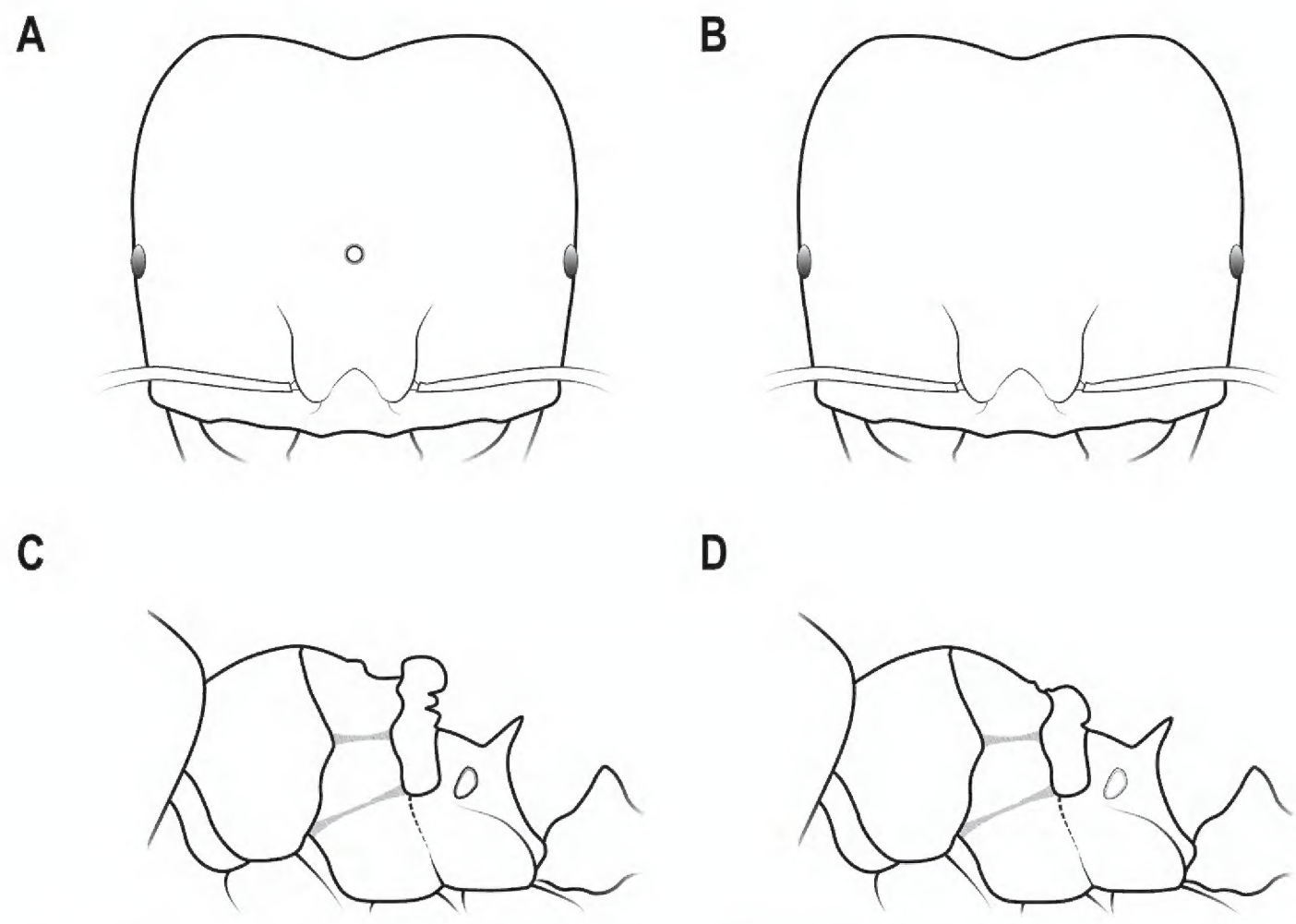

Figure 4. Head in full-face view and mesosoma in lateral view (the largest major worker) **A** head with an ocellus **B** head with no ocelli **C** mesoscutellum strongly convex **D** mesoscutellum broadly convex.

5 Largest major worker distinctly smaller with TL 11–12 mm..... ..... ***C. diversa draco* (Santschi, 1920)**

– Largest major worker distinctly larger with TL ~ 16 mm..... **6**

6 The posterior quarter of the head with transverse and very large wrinkles; the smooth frontal space more extensive (Fig. 5A)..... ..... ***C. diversa laotina* (Santschi,1920)**

– The posterior 1/3 of head with diverged wrinkles; smooth frontal space more narrowed (Fig. 5B) ..... ***C. diversa* (Jerdon)**

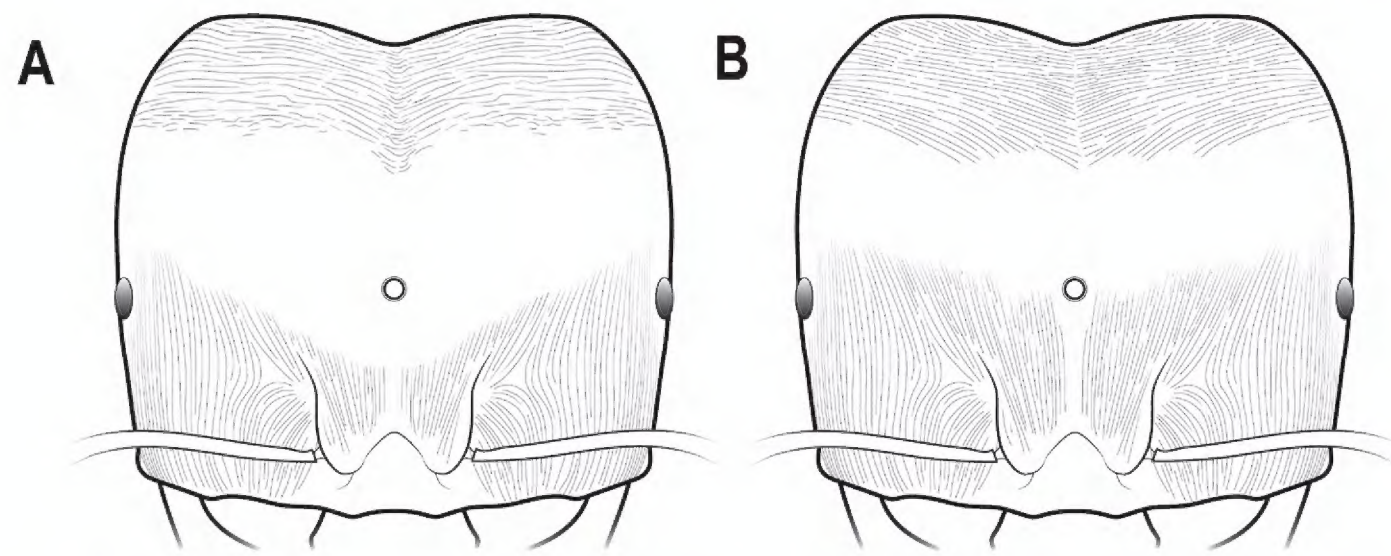

Figure 5. Heads of *C. diversa* and *C. diversa laotina* in full-face view (the largest major worker) **A** *C. diversa laotina*, head with broader smooth space, wrinkles mostly transverse **B** *C. diversa*, head with more narrowed smooth space, wrinkles fine and diverged.

7 Propodeal spines curving forward and inclined (Fig. 6A) ..... ***C. yanoi* (Forel)**
– Propodeal spines directed backwards or erect (Fig. 6B)..... **8**

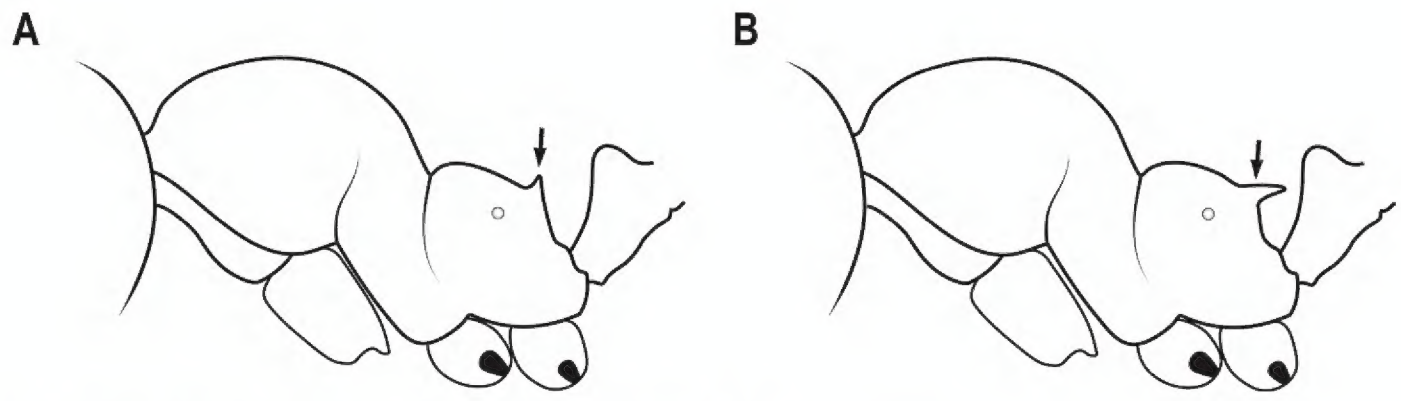

Figure 6. Pronotal spines **A** curving forward **B** backwards.

8 Promesonotum slightly convex in lateral view; first tergite of gaster > 2× as wide as second tergite ..... ***nanningensis* (Li & Tang)**
– Promesonotum distinctly convex in lateral view; first gastric tergum almost as wide as second tergum ..... ***C. affinis* (Jerdon)**
9 Head and body mostly smooth and shiny (Fig. 7A) **10**
– Head and body coarsely striate (Fig. 7B)..... **12**

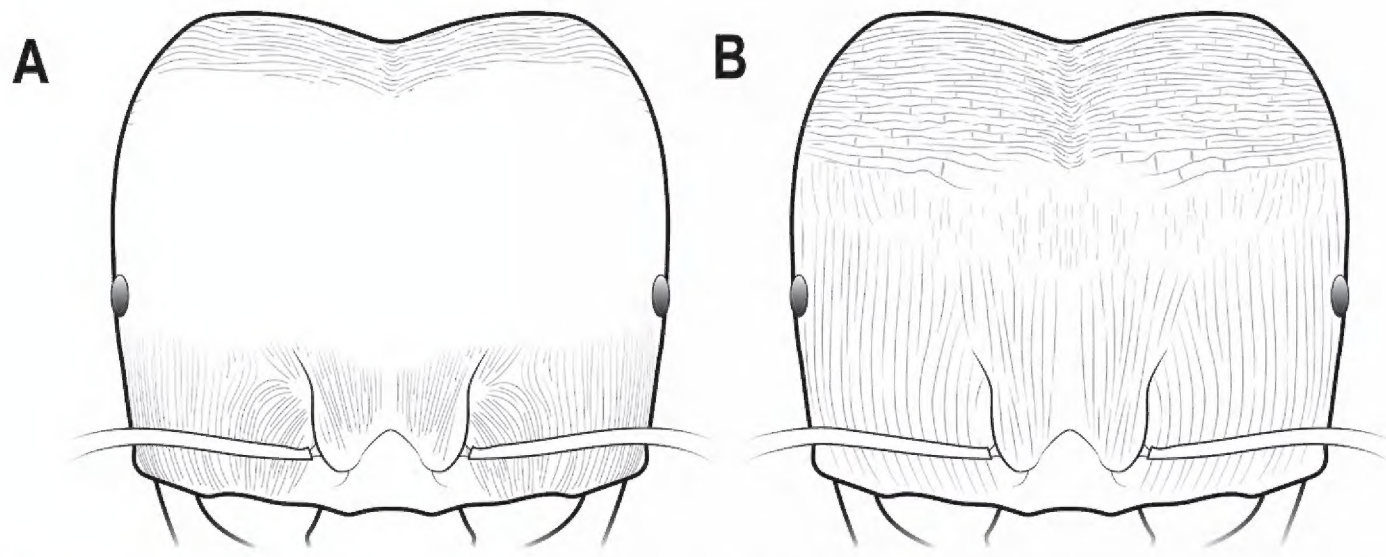

Figure 7. Head in full-face view **A** head mostly smooth and shiny **B** head mostly striate.

10 Propodeal spines pointing backwards in the largest major worker; petiolar node broadly rounded above in profile view; head without a coarse black line in median longitudinal groove (Fig. 8A, C) ..... ***C. latinoda* (Zhou & Zheng)**
– Propodeal spines curving forward in the largest major worker; petiolar node narrowed above, triangular in profile view; head with a coarse black line in median longitudinal groove (Fig. 8B, D) **11**

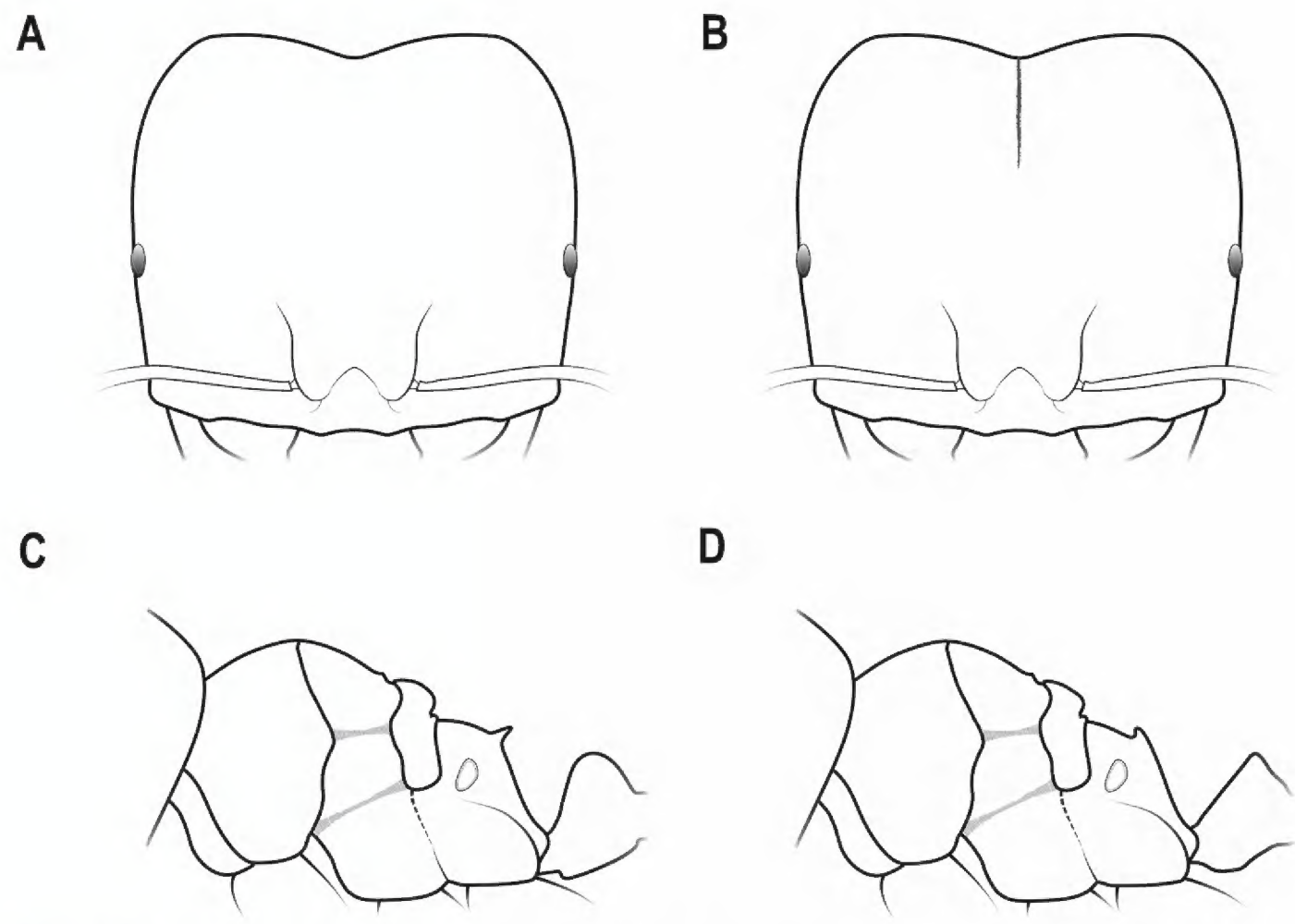

Figure 8. Head in full-face view, mesosoma and petiole in lateral view **A** head without a coarse black line **B** head with a coarse black line in median longitudinal groove **C** propodeal spines pointing backward, petiolar node round above **D** propodeal spines curving forward, petiolar node narrowed above.

11 Postpetiole approximately as long as wide; hairs sparse (Fig. 9A, C) ..... ***C. vespillo* (Wheeler)**

– Postpetiole distinctly broader than long; hairs abundant (Fig. 9B, D)..... ***C. melasolena* (Zhou & Zheng)**

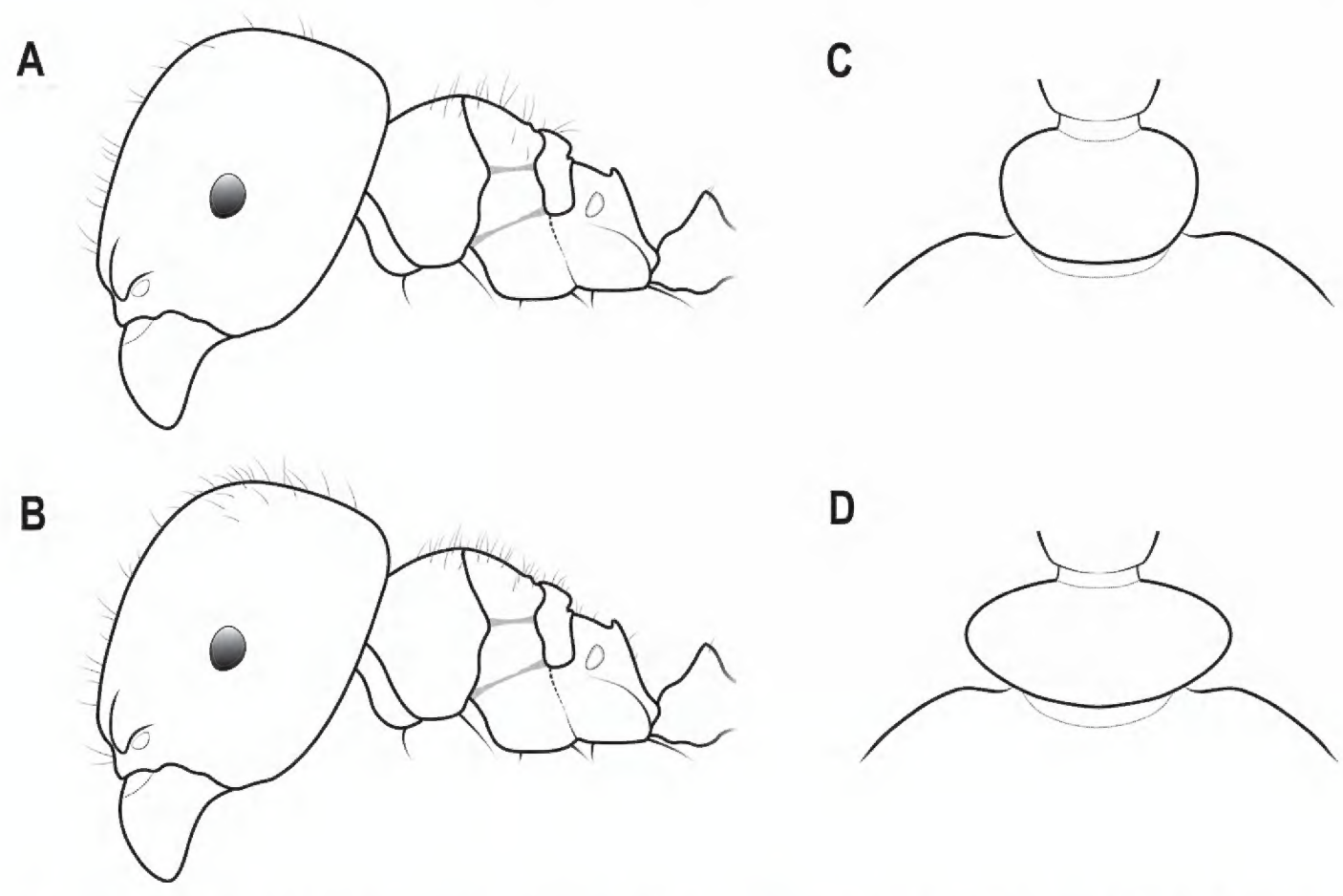

Figure 9. Head and mesosoma in lateral view, postpetiolar node in dorsal view **A** *C. vespillo*, hairs sparse **B** *C. melasolena*, hairs abundant **C** *C. vespillo*, postpetiolar node nearly as long as wide **D** *C. melasolena*, postpetiolar node distinctly wider than long.

12 Propodeal spines laterally compressed and curving forward; mandibles with longitudinal striations on the base in full-face view; interspaces on the head between striations punctured (Fig. 10A, C)..... .....***C. trechideros* Zhou & Zheng**

– Propodeal spines thick and straight, not curved; mandibles smooth in full-face view; interspaces between striations smooth (Fig. 10B, D)..... .....***C. zengchengensis* (Zhou et al.)**

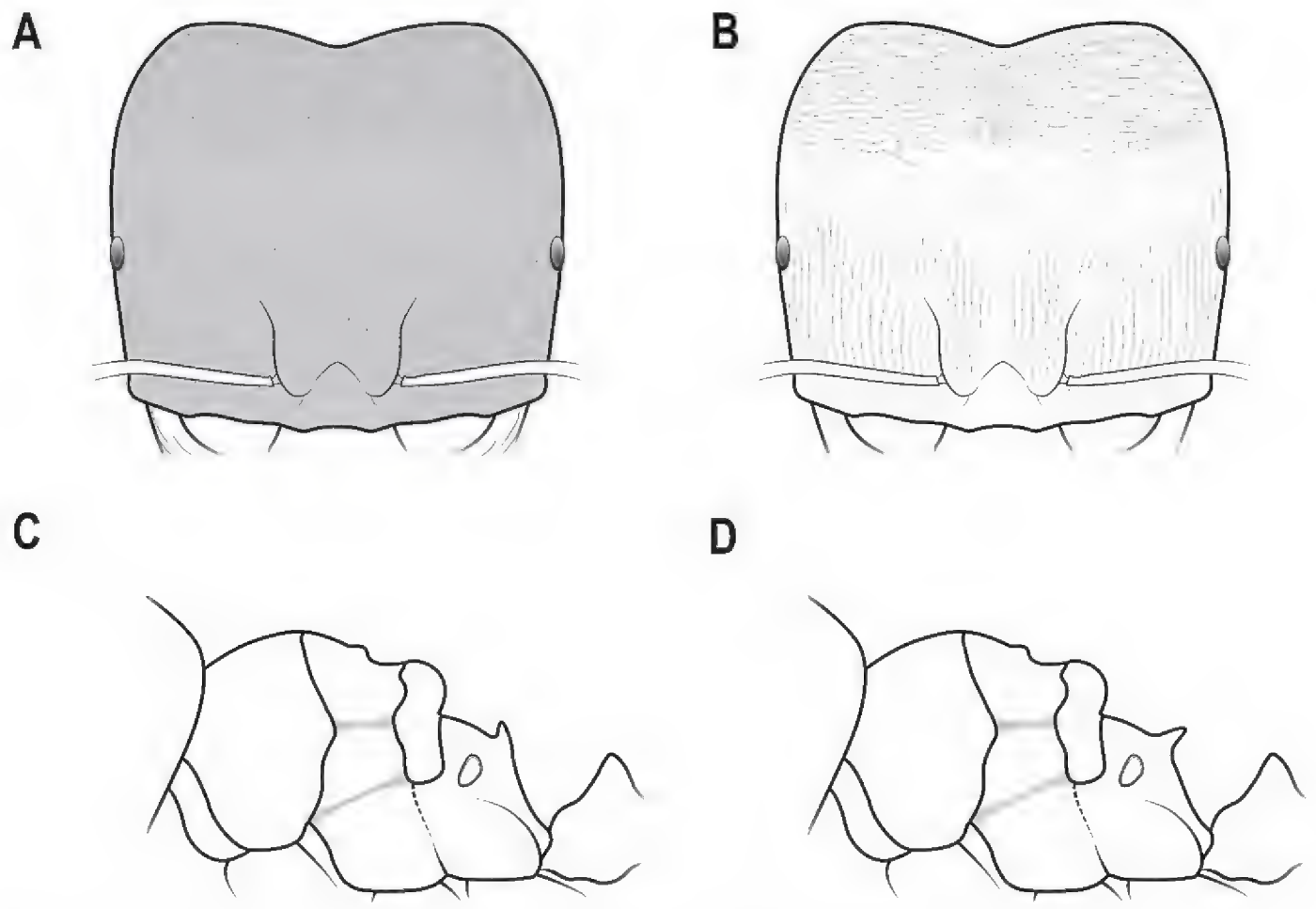

Figure 10. Head in full-face view and mesosoma in lateral view (the largest major worker) **A** head of *C. trechideros*, mandibles with longitudinal striations, interspaces between striations punctured **B** head of *C. zengchengensis*, mandibles without striations, interspaces between striations smooth **C** propodeal spines curving forward **D** propodeal spines straight and not curved.

13 Mandible with 5 teeth on masticatory margin (Fig. 11A) **14**

– Mandible with 6 teeth on masticatory margin (Fig. 11B) **16**

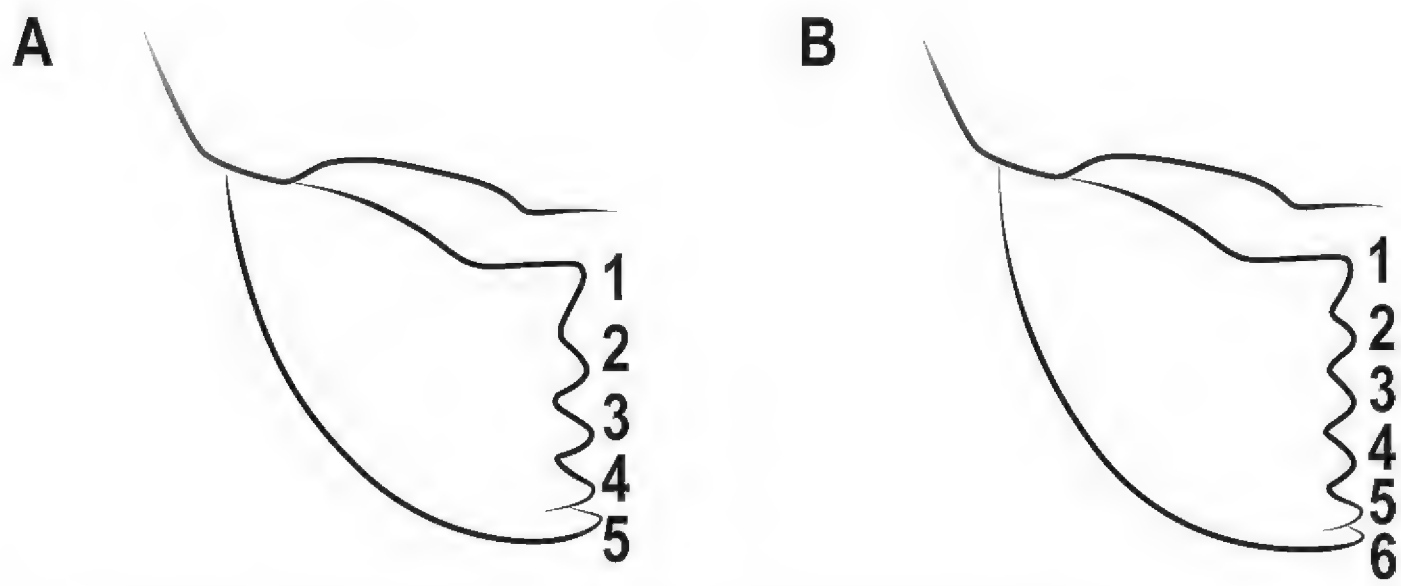

Figure 11. Mandibles **A** mandible with 5 teeth **B** mandible with 6 teeth.

14 Posterolateral corners of head with minute tubercles; eyes present; head slightly longer than wide (Fig. 12A).....***C. altinodus* (Xu)**
– Posterolateral corners of head with developed horns; eyes absent; head distinctly longer than wide (Fig. 12B).....**15**

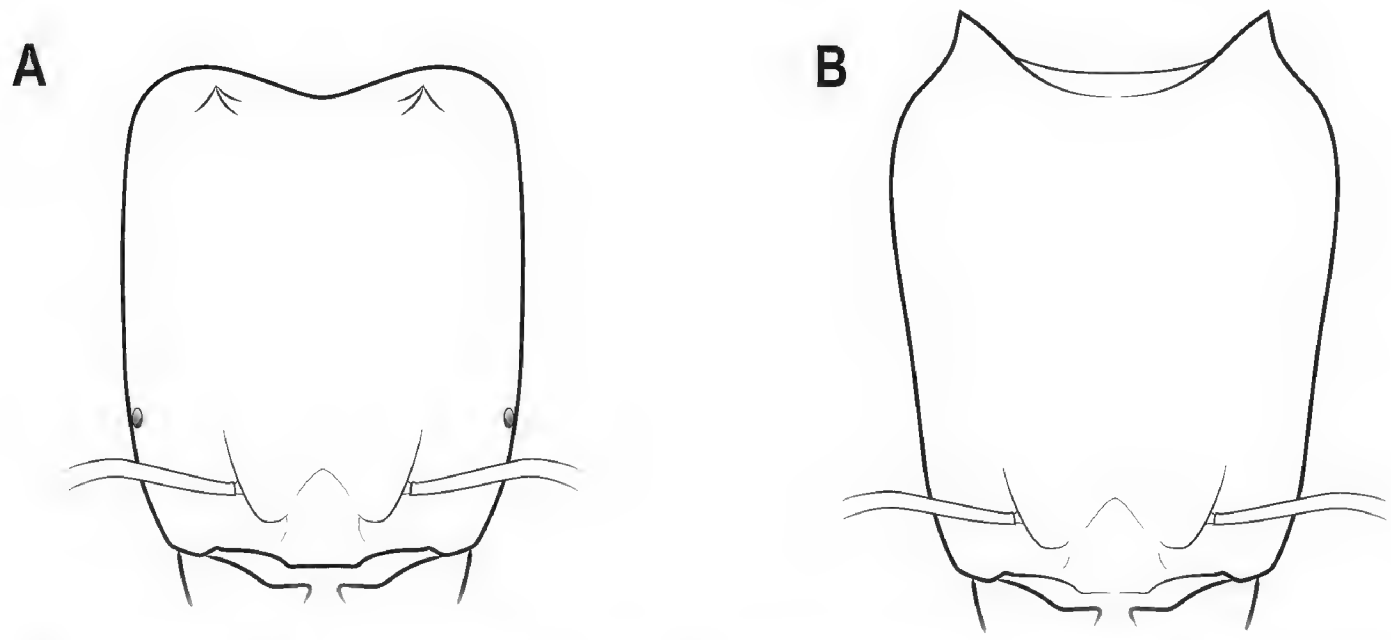

Figure 12. Horns **A** posterolateral corners of head with minute tubercles **B** posterolateral corners of head with developed horns.

15 Head broader behind than in front with more punctures; head and thorax with dense hairs ..... ***C. capreola* (Wheeler)**
– The posterior portion of head almost as wide as the anterior portion; head with less punctures, smoother and more shiny; head and thorax with sparser and shorter hairs.....***C. capreola laeviceps* (Wheeler)**
16 Eyes absent; propodeal denticles downwardly inclined; first segment of gaster finely punctuate (Fig. 13A) .....***C. curvispina* (Xu)**
– Eyes present; propodeal denticles dorsoposteriorly pointed; first segment of gaster densely longitudinally striate (Fig. 13B).....***C. striata* (Xu)**

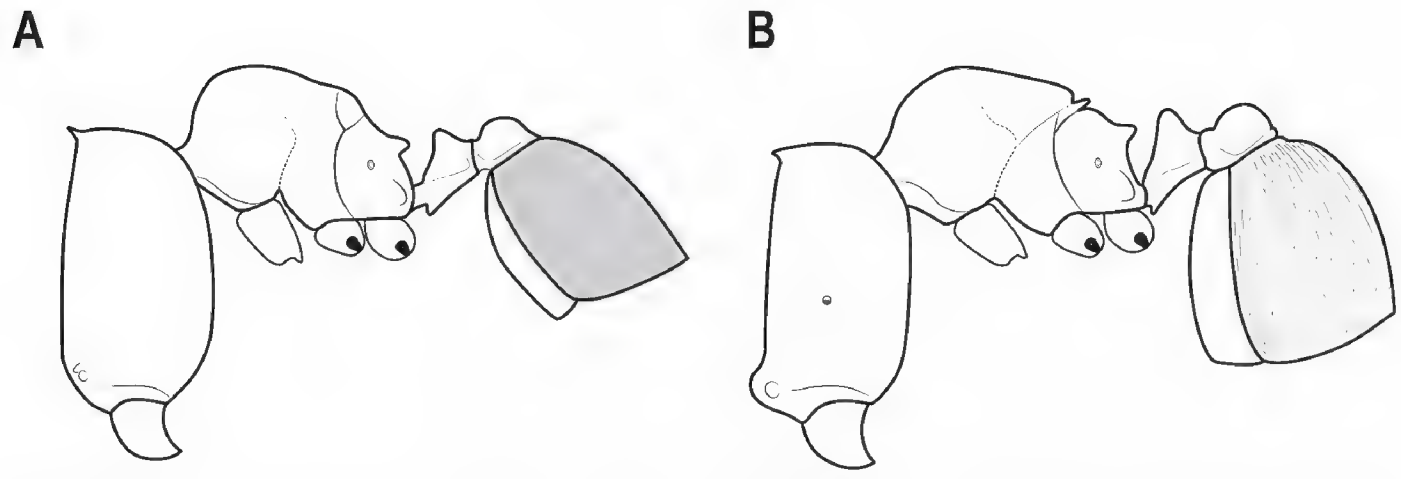

Figure 13. Two *Carebara* species in lateral view **A** *C. curvispina*, propodeal denticles down-inclined, first segment of gaster finely punctuate, eyes absent **B** *C. striata*, propodeal denticles dorsoposteriorly pointed, first segment of gaster densely longitudinally striate, eyes present.

17 Mandible with 6 teeth on masticatory margin (Fig. 14C) **18**
– Mandible with 4 or 5 teeth on masticatory margin (Fig. 14A, B).....**19**

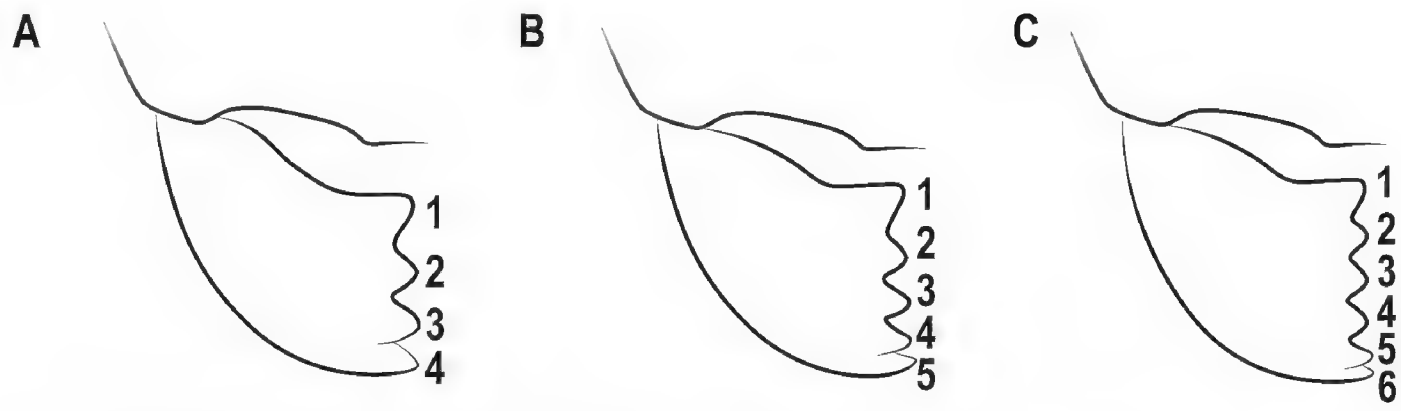

Figure 14. The number of teeth **A** 4-teethed **B** 5-teethed **C** 6-teethed.

18 HL < 1 mm; first gastral tergum smooth and shiny.....***C. oni* (Terayama)**
– HL > 1 mm; first gastral tergum punctate and microreticulate with longitudinal striations (Fig. 15A, B).....***C. qianliyan* Terayama**

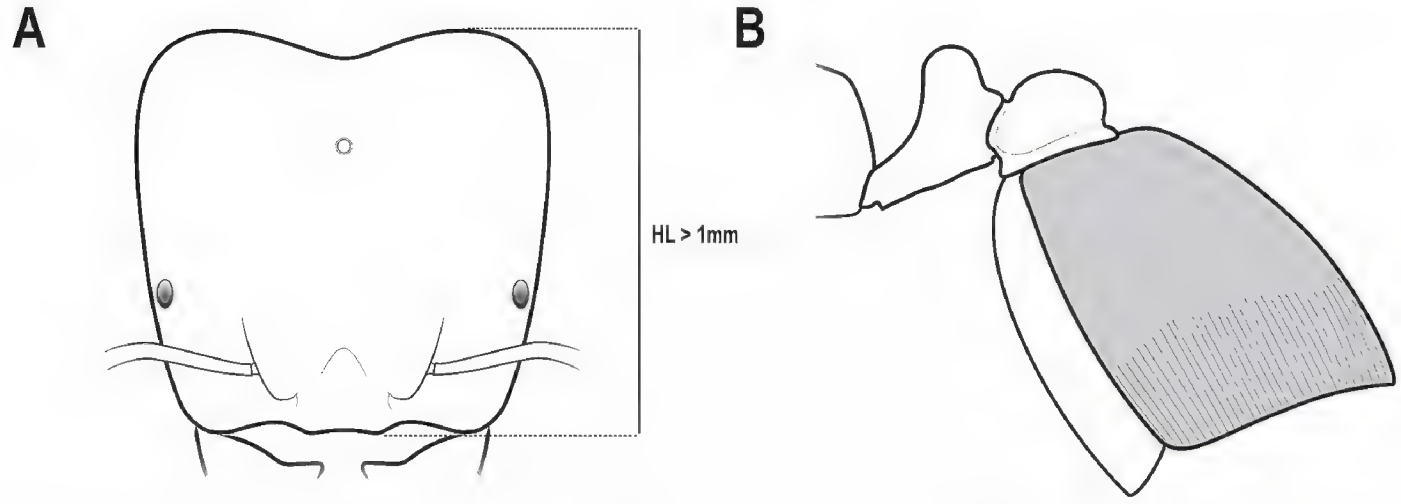

Figure 15. Head in full-face view and tergum in lateral view (*C. qianliyan*) **A** HL > 1 mm **B** first gastral tergum punctate with longitudinal striations.

19 Posterolateral corners of head with a pair of distinct horns or small tubercles (Fig. 16A, B).....**20**
– Head with no horns or tubercles (Fig. 16C).....**29**

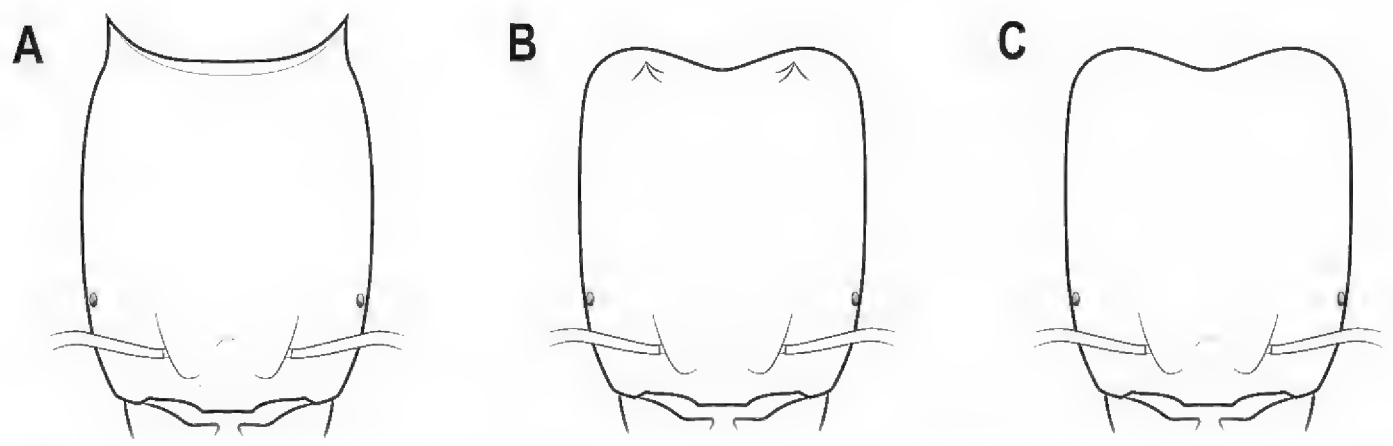

Figure 16. Horns or tubercles on the posterior corner of head **A** distinct horns **B** small tubercles **C** no horns or tubercles.

20 Propodeum with a pair of protruding denticles (Fig. 17A) **21**
– Propodeum without a pair of protruding denticles; posterodorsal corner of propodeum rounded or forms an obtuse or right angle (Fig. 17B, C).....**23**

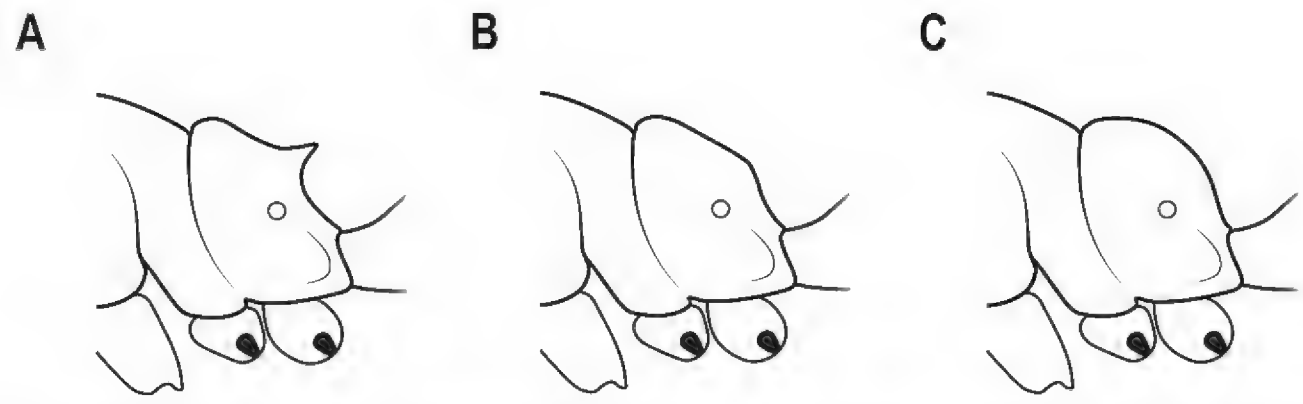

Figure 17. Propodeum in lateral view **A** propodeum with protruding denticles **B** propodeum forming an obtuse angle **C** propodeum rounded.

21 Posterior area of head without transverse striations; metanotal groove impressed shallowly; body smaller with TL 1.4 mm (Fig. 18C) ..... ***C. acutispina* (Xu)**

– Posterior area of head with transverse striations; metanotal groove deeply impressed; body larger with TL 2.1–2.6 mm (Fig. 18A, B) **22**

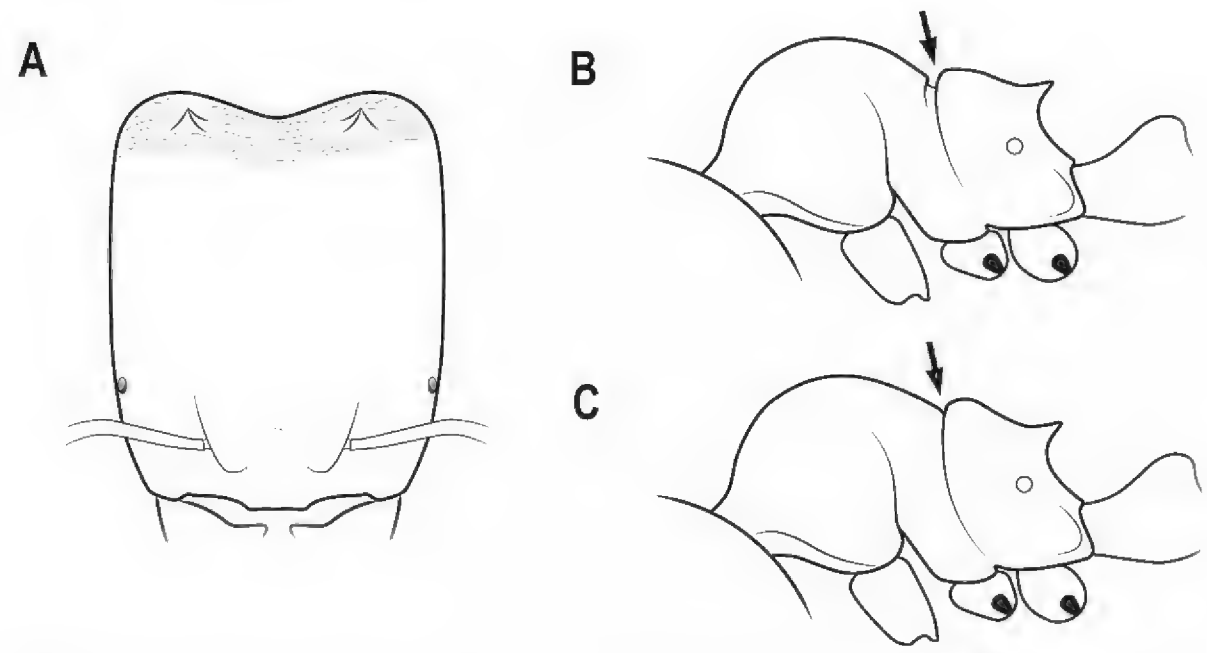

Figure 18. Striations and metanotal groove **A** head with transverse striations **B** metanotal groove impressed deeply **C** metanotal groove impressed shallowly.

22 Mandible with 4 teeth on masticatory margin; clypeus with the anterior margin of median portion concave indistinctly..... ***wheeleri* (Ettershank)**

– Mandible with 5 teeth on masticatory margin; clypeus with the anterior margin of median portion concave distinctly..... ***C. obtusidenta* (Xu)**

23 Horns connected by a developed transverse ridge (Fig. 19A) **24**

– Horns not connected by a developed transverse ridge (Fig. 19B) **25**

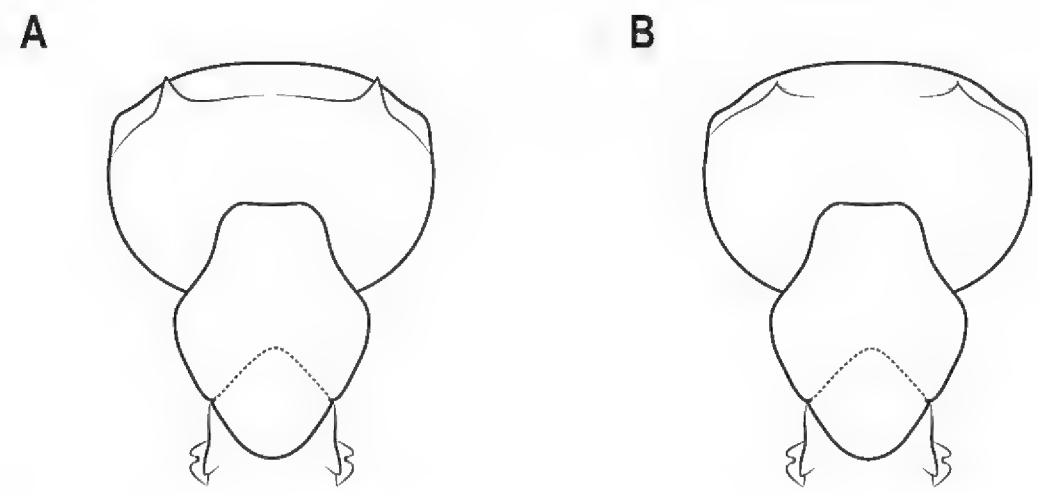

Figure 19. Horns in dorsal view **A** horns connected by a transverse ridge **B** horns not connected by a transverse ridge.

24 Head capsule thin with straight anterior margin in lateral view (Fig. 20A) .... ***C. bihornata* (Xu)**

– Head capsule thick with convex anterior margin in lateral view (Fig. 20B).... ..... ***C. sakamotoi* Terayama et al.**

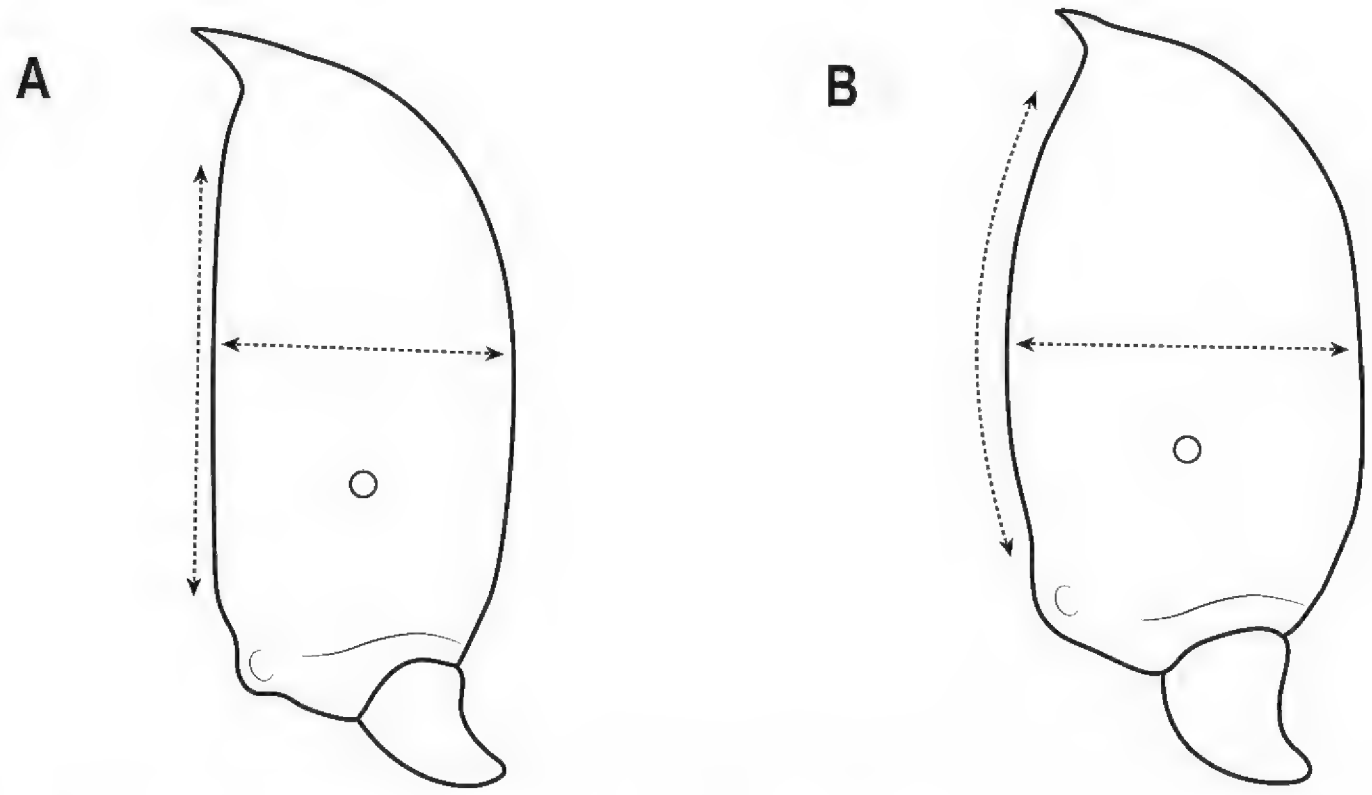

Figure 20. Head capsule in lateral view **A** head capsule thin with anterior margin straight **B** head capsule thick with anterior margin convex.

25 Body larger with TL 3.0–3.5 mm ..... ***C. polyphemus* (Wheeler)**

– Body smaller with TL 1.5–2.3 mm **26**

26 Mandible with 4 teeth on masticatory margin..... ***C. taiponica* (Wheeler)**

– Mandible with 5 teeth on masticatory margin.....**27**

27 Head coarsely microreticulate; frons and vertex with many striae (Fig. 21A) .....***C. yamatonis* (Terayama)**

– Head largely smooth and shiny (Fig. 21B).....**28**

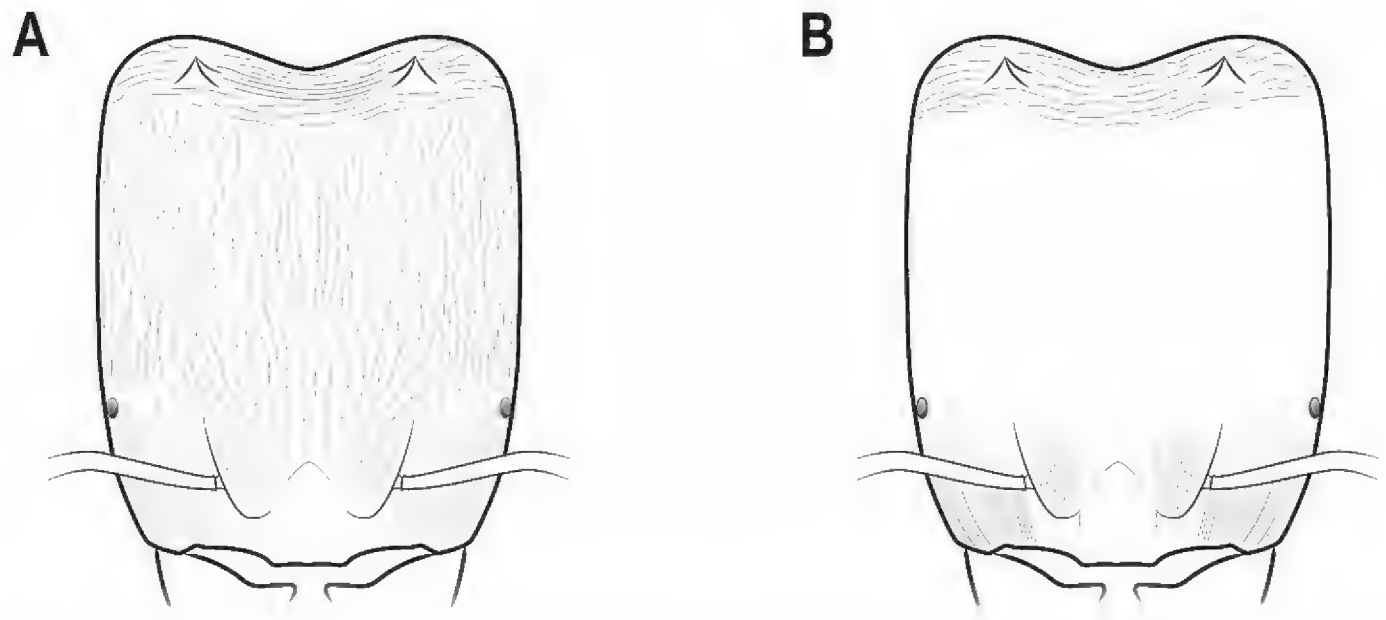

Figure 21. Head in full-face view **A** head with dense microreticulation **B** head largely smooth and shiny.

28 Anterodorsal corner of propodeum prominent, forming an acute tooth behind metanotal groove (Fig. 22A).....***C. sauteri* (Forel)**

– Anterodorsal corner of propodeum not forming an acute tooth (Fig. 22B) ....
.....***C. rectidorsa* (Xu)**

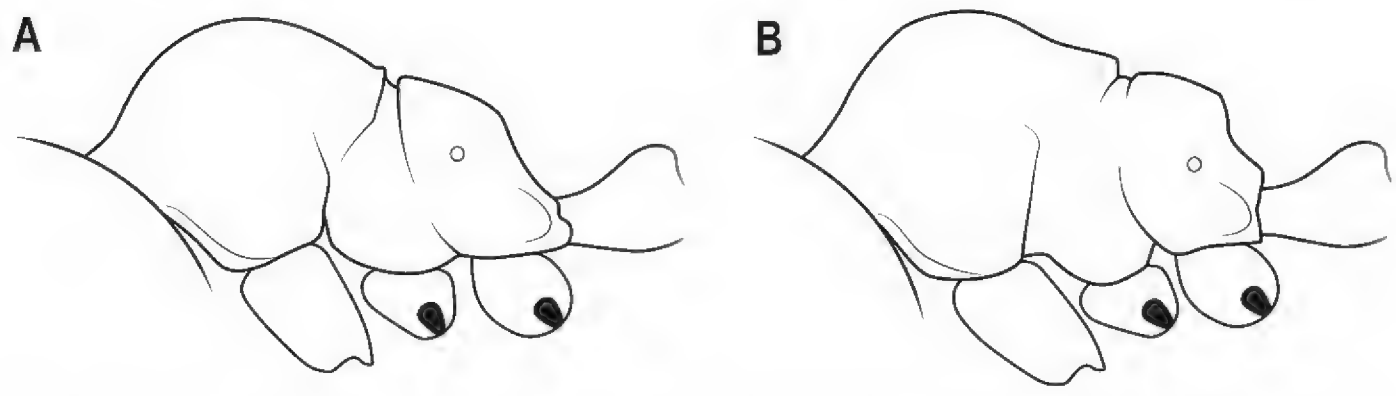

Figure 22. Mesosoma in lateral view **A** anterodorsal corner of propodeum forming an acute tooth **B** anterodorsal corner of propodeum not forming an acute tooth.

29 Head nearly square, ~ as long as broad; eyes with 16 facets; head with 3 ocelli; dorsum of mesosoma straight (Fig. 23A, B)..... ***C. hunanensis* (Xu)**

– Head rectangular, longer than broad; eyes with < 10 facets; head without ocelli; dorsum of mesosoma not straight.....**30**

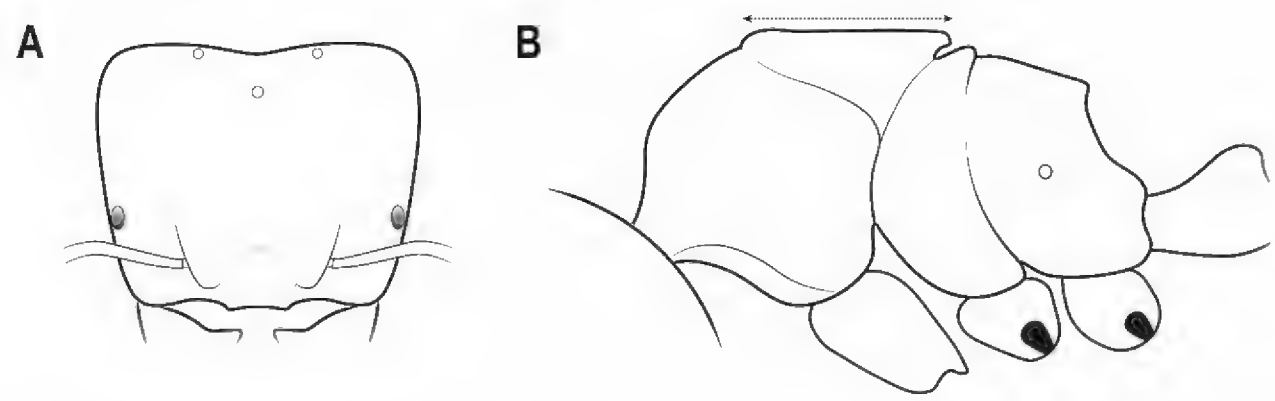

Figure 23. *C. hunanensis* **A** head with 3 ocelli in full-face view **B** dorsum of mesosoma straight in lateral view.

30 Propodeum with a pair of acute teeth; head with fine reticulations .....
..... ***C. reticapita* (Xu)**

– Propodeum forms an obtuse angle; head smooth, at most sparsely punctured **31**

31 Posterodorsal corner of propodeum forming a right angle of ~ 90° (Fig. 24A) ..... ***C. pseudolusciosa* (Wu & Wang)**

– Posterodorsal corner of propodeum forming an obtuse angle of more than 90° (Fig. 24B).....**32**

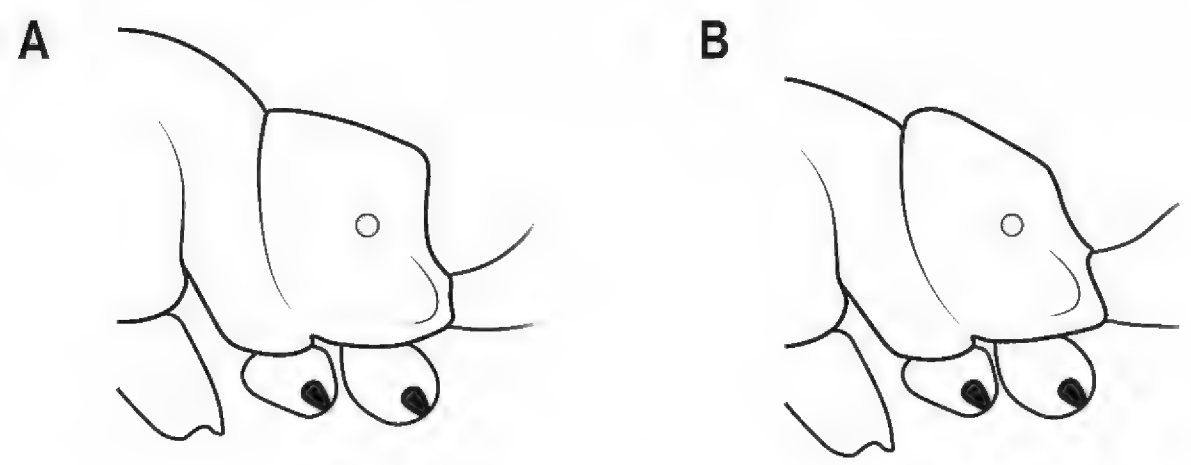

Figure 24. Propodeum in lateral view **A** posterodorsal corner forming an right angle **B** posterodorsal corner forming an obtuse angle.

32 Vertex with transverse striations..... ***C. jiangxiensis* (Wu & Wang)**
– Vertex smooth and with no striations.....**33**
33 Antenna 10-segmented; katepisternum rugose-reticulate; body distinctly larger with TL > 2.6 mm (Fig. 25A).....***C. laeviceps* sp. nov.**
– Antenna 9-segmented; katepisternum smooth and shiny; body smaller with TL ~ 2 mm (Fig. 25B).....***C. lusciosa* (Wheeler)**

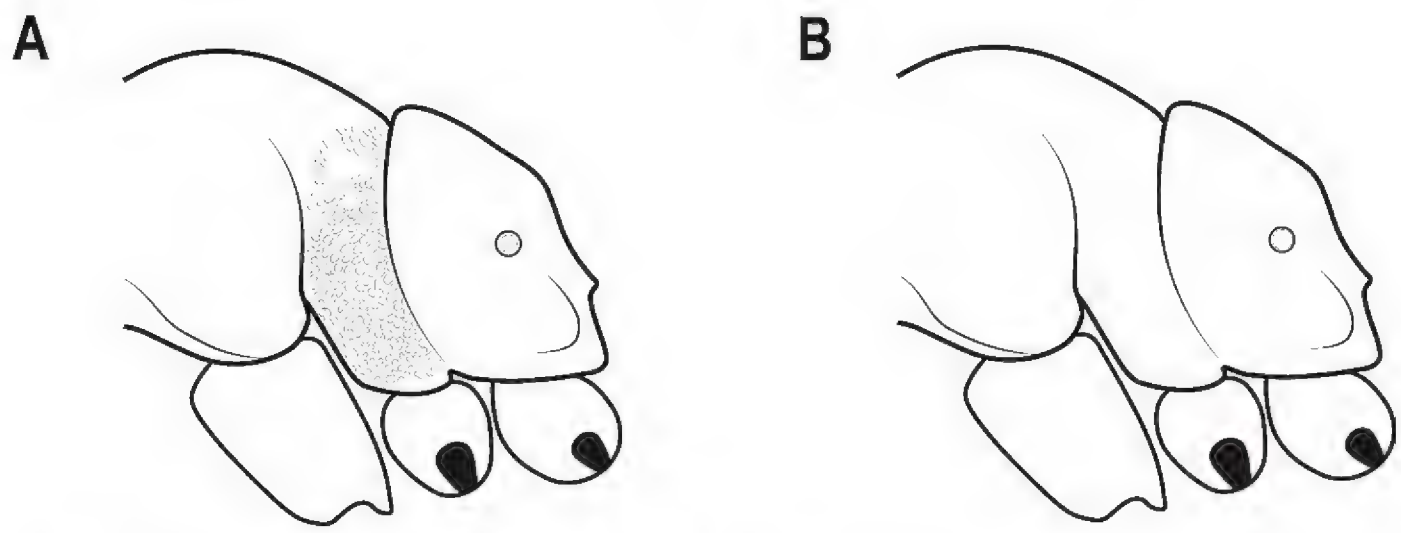

Figure 25. Katepisternum in lateral view **A** katepisternum rugose-reticulate **B** katepisternum smooth.

***Carebara laeviceps* Liu & Zhong, sp. nov.**
https://zoobank.org/A584356D-EADC-4344-9142-4F34D030F4DE
Figs 26–31

Type material. SWFU; ***Holotype*.** China: 1 major worker, Sichuan Province, Dazhou City, Kaijiang County, 31°12'24"N, 107°55'43"E, alt. 1100 m, 27.VI.2022, Gui-chuan Nie, SWFU A22-955. ***Paratypes*.** China: 3 major workers and 4 minor workers, same data as holotype, SWFU A22-955.

Description of major worker. ***Measurements*.** Holotype major worker: HL 0.84, HW 0.63, EL 0.02, SL 0.38, WL 0.73, PNW 0.42, PNH 0.29, MNH 0.48, PDH 0.32, PTL 0.30, PTH 0.23, PTW 0.22, PPL 0.21, PPH 0.18, PPW 0.25, CI 75, SI 60, EI 3, LPpI 117, DPpI 119, PpWI 114, PpLI 70, PpHI 78, PPI 60. Paratype major workers (*n* = 3): HL 0.88 (0.85–0.90), HW 0.68 (0.66–0.70), EL 0.03 (0.02–0.05), SL 0.36 (0.35–0.36), WL 0.76 (0.75–0.78), PNW 0.43 (0.42–0.44), PNH 0.33 (0.31–0.35), MNH 0.44 (0.43–0.44), PDH 0.33 (0.30–0.35), PTL 0.30 (0.26–0.33), PTH 0.23 (0.22–0.23), PTW 0.20 (0.19–0.20), PPL 0.17 (0.14–0.19), PPH 0.18 (0.15–0.20), PPW 0.26 (0.25–0.27), CI 78 (77–78), SI 52 (51–55), EI 4.38 (3–7.14), LPpI 107 (94–127), DPpI 144 (131–153), PpWI 132 (130–135), PpLI 59 (57–61), PpHI 75 (65–83), PPI 60 (58–61). ***Head*.** Large, subrectangular with lateral margins straight and parallel in full-face view, distinctly longer than broad, ~ 1.3× as long as wide; posterior margin slightly concave medially; posterolateral corner rounded and without horns in lateral view. Mandible triangular with five teeth on the masticatory margin. Clypeus steep and flat in lateral view; anterior margin of clypeus nearly straight with median portion indistinctly concave. Frontal lobes concealing condylar bulb. Ocelli absent. Eyes minute, located a little behind the anterior 1/3 length of head, ~ 0.3 mm from mandibular insertions to eyes. Antenna 10-segmented with a 2-segmented club; scape short, ~ 0.4× as long as HL; apex of scape below mid-length of distance from antennal insertion to vertexal corner when scape is laid back. Dorsum of head

flat in lateral view. ***Mesosoma*.** In lateral view, promesonotum slightly convex with moderately rounded dorsum; the sides of pronotum strongly convex and rounded in dorsal view; promesonotal suture indistinct. Metanotal groove deeply impressed. Anterodorsal corner of propodeum forms an acute tooth behind the metanotal groove in lateral view; propodeum lower than promesonotum with flat dorsum; the declivity and dorsum of propodeum forming an obtuse angle in lateral view; declivitous edge of propodeum with a pair of indistinct carinae; lateral margins of propodeum strongly convex in dorsal view. ***Waist*.** Petiole ~ 0.8× as high as long with a long peduncle; petiolar node wider than long in dorsal view. In lateral view, the peduncle without angled tooth in antero-ventral corner and the ventral margin of peduncle slightly convex; dorsum of petiole rounded in lateral view; anterior and posterior surfaces of petiolar node moderately convex. Postpetiolar node slightly lower than petiolar node, roundly convex. In dorsal view, postpetiole wider than petiole (PPW 0.25, PTW 0.22), both petiolar and postpetiolar nodes with convex lateral margins. ***Gaster*.** Long and oval. ***Sculpture and hairs*.** Mandibles, Median portion of clypeus and area from frons to posterior margin of head smooth and shiny, except genae and frontal lobes longitudinally striate. Posterior area of head without striations or carinae. Dorsum and lateral face of pronotum mostly smooth and shiny; anterior face of pronotal disc with fine reticular rugae. Mesonotum smooth; anepisternum and katepisternum strongly rugose-reticulate. In dorsal view, metanotal groove with several longitudinally parallel rugulae; propodeum mostly smooth in dorsal view; lateral face and declivity of propodeum weakly rugose-reticulate and with indistinct transverse rugulae in lateral view. Dorsum of petiolar node smooth; the lateral faces of node and peduncle rugose-reticulate; postpetiole weakly reticulate in dorsal view; ventral area of petiole and postpetiole strongly reticulate in lateral view. Gaster smooth and shiny. Head capsule covered with erect to subdecumbent hairs; while hairs on scapes and mandibles mostly decumbent. Dorsum of pronotum and mesonotum with abundant long erect hairs in lateral view; hairs on lateral face of mesosoma and dorsum of propodeum much sparser. Dorsum of petiole and postpetiole, and gaster with long erect to decumbent hairs; the ventral margin of petiole and postpetiole with no hairs in lateral view. ***Color*.** Head yellowish brown with clypeus and genae slightly darker; masticatory margin of mandible black. Mesosoma and petiole yellowish brown. Color of appendages and gaster paler.

Description of minor worker. *Measurements*. Paratype minor workers (*n* = 4): HL 0.46 (0.44–0.48), HW 0.44 (0.42–0.46), EL 0.01, SL 0.31 (0.30–0.32), WL 0.52 (0.51–0.52), PNW 0.28 (0.27–0.29), PNH 0.20 (0.20–0.21), MNH 0.29 (0.27–0.31), PDH 0.21 (0.19–0.23), PTL 0.18 (0.17–0.19), PTH 0.15 (0.14–0.15), PTW 0.13 (0.12–0.13), PPL 0.12 (0.11–0.12), PPH 0.11 (0.10–0.11), PPW 0.16, CI 94 (88–98), SI 70 (65–74), EI 2, LPpI 110 (100–120), DPpI 139 (133–145), PpWI 128 (123–133), PpLI 64 (61–71), PpHI 73 (67–79), PPI 57 (55–59). ***Head*.** Much smaller (HL 0.44–0.48, HW 0.42–0.46) than the head of major worker. In full-face view head subquadrate with lateral margins convex, slightly longer than broad and narrowed both anteriorly and posteriorly, ~ 1.1× as long as wide. Posterior margin of head slightly concave medially, posterolateral corners rounded in full-face view. Dorsum of head broadly convex in lateral view. Anterior margin of clypeus almost straight. Mandible triangular with five teeth on masticatory margin. Eyes minute, situated at the anterior 1/2

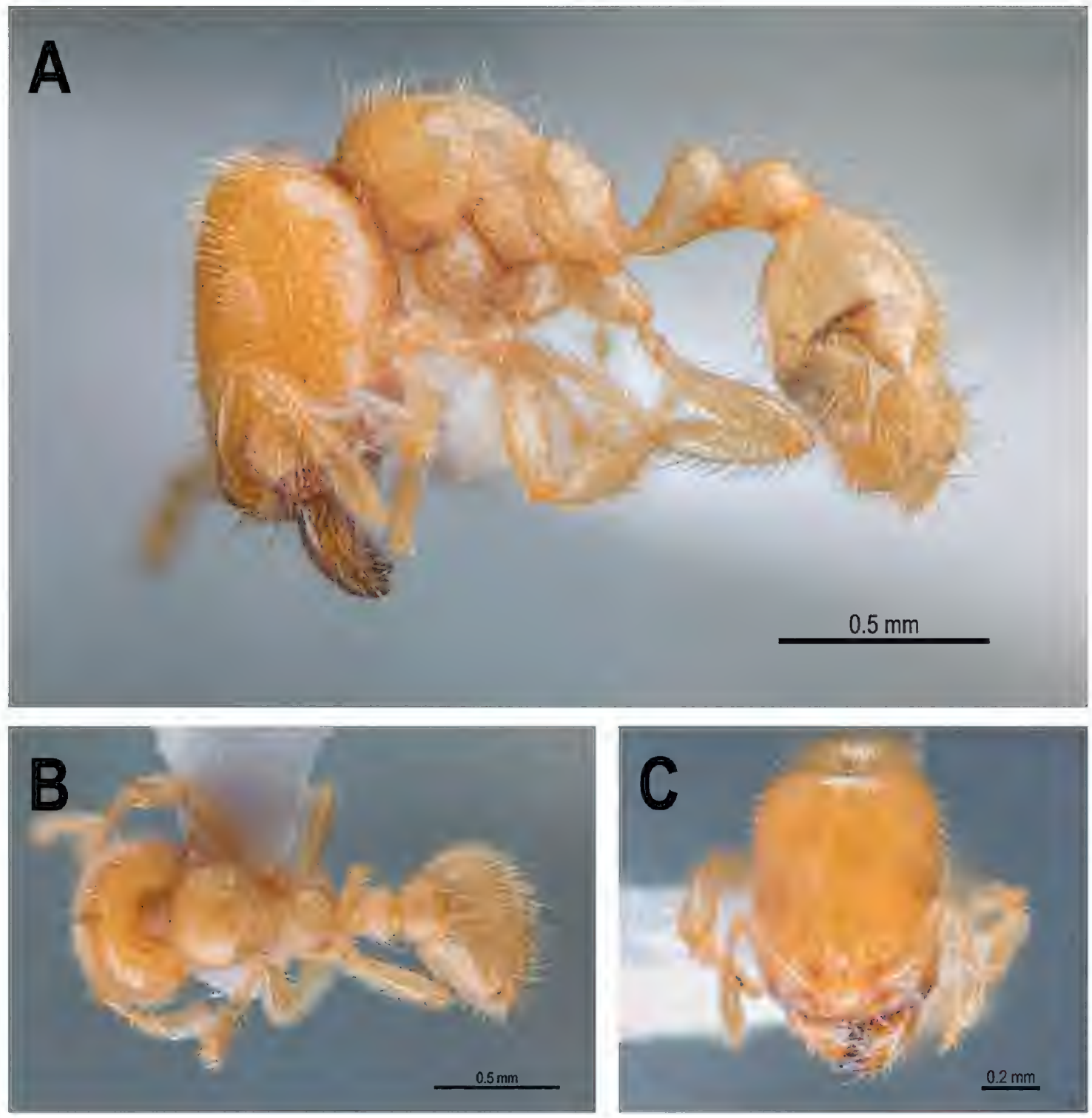

Figure 26. *Carebara laeviceps* Liu & Zhong, sp. nov. Holotype (major worker) **A** body in lateral view **B** body in dorsal view **C** head in full-face view.

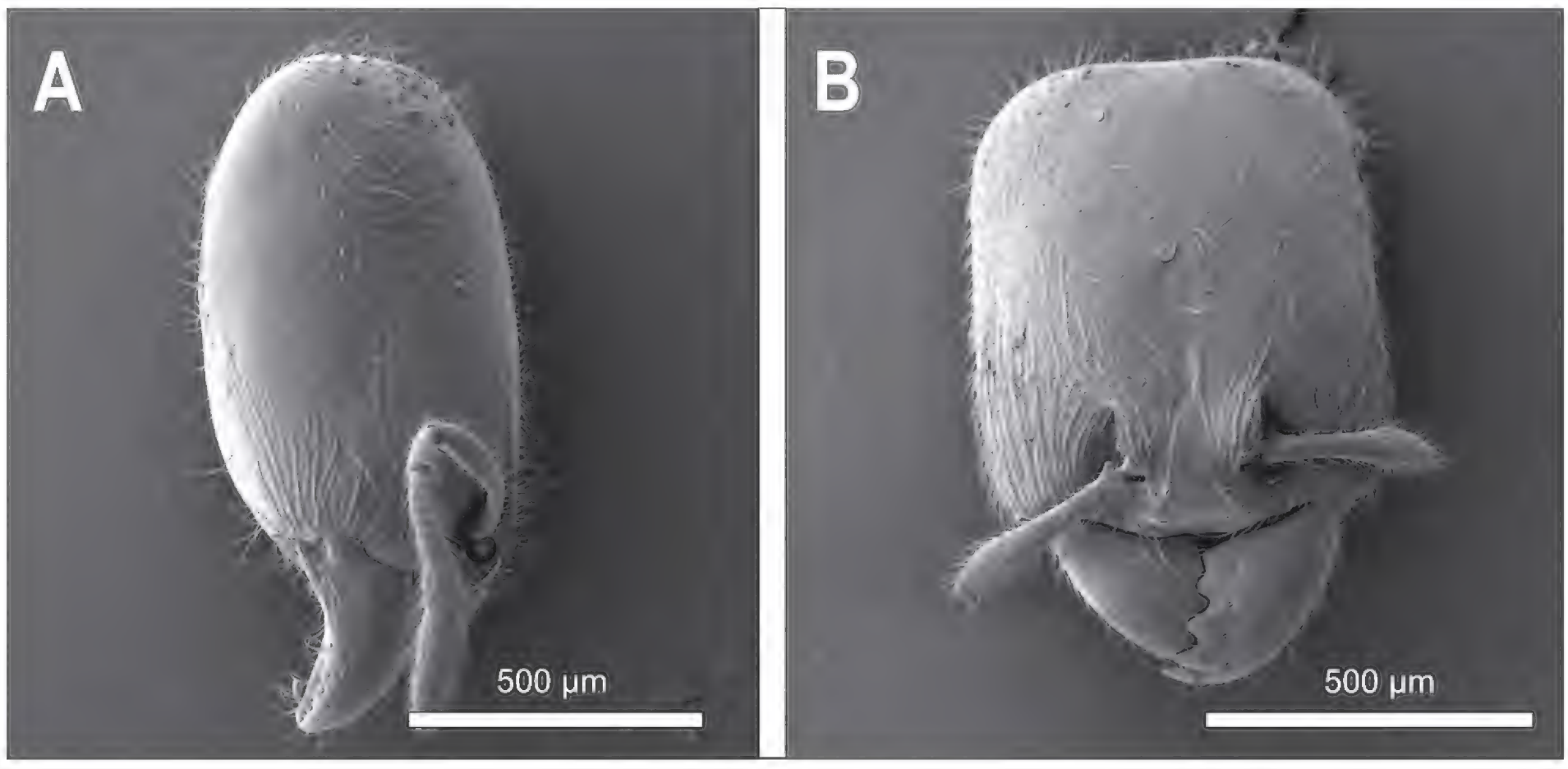

Figure 27. *Carebara laeviceps* Liu & Zhong, sp. nov. Major worker under SEM (not holotype) **A** head in lateral view **B** head in full-face view.

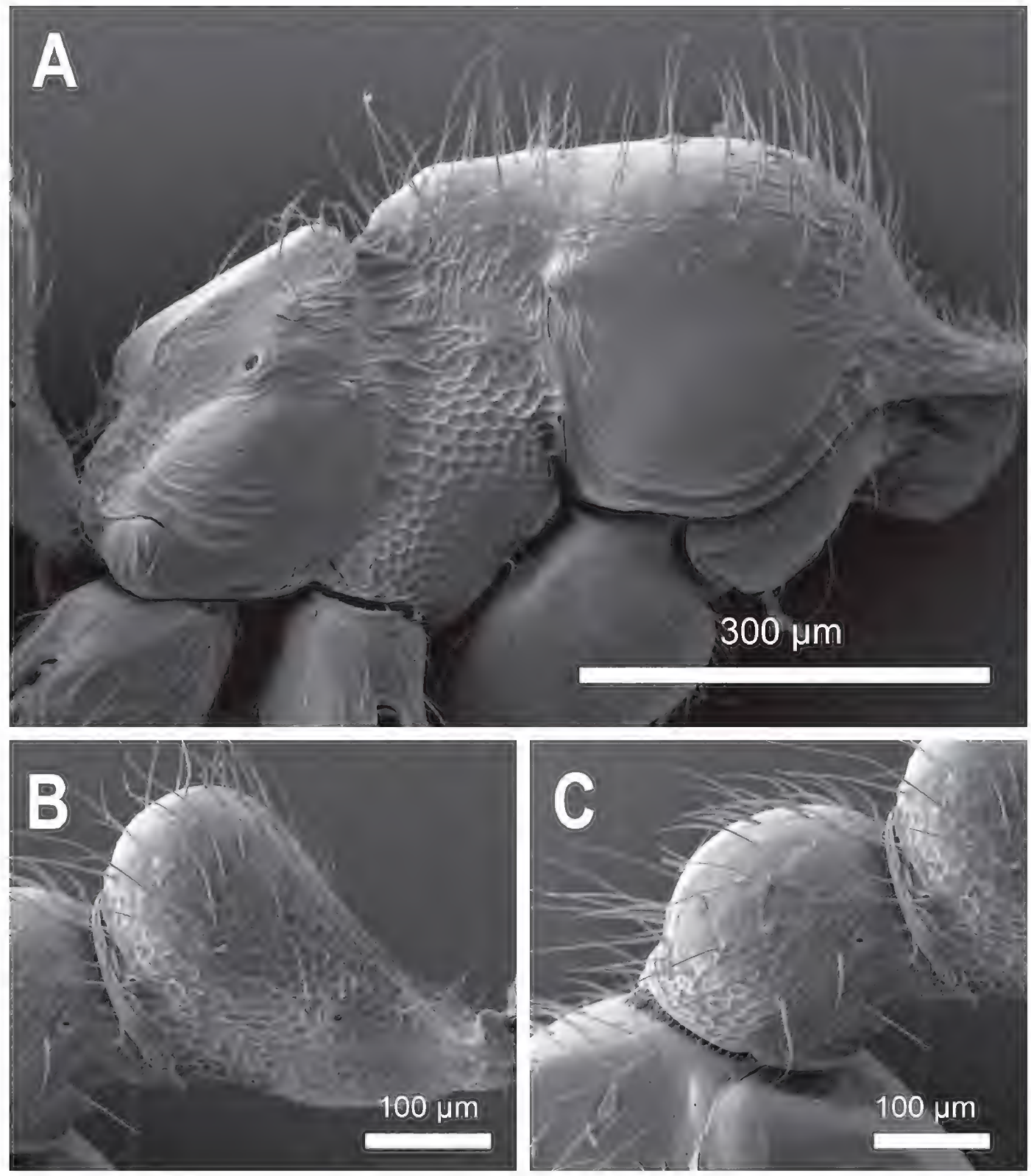

Figure 28. *Carebara laeviceps* Liu & Zhong, sp. nov. Major worker under SEM (not holotype) **A** mesosoma in lateral view **B** petiole in lateral view **C** postpetiole in lateral view.

length of head, ~ 0.2 mm from mandibular insertions to eyes. Antenna 10-segmented with a 2-segmented club; scape 0.70× as long as HW; apex of scape reaching 3/5 of the distance from antennal insertion to vertexal corner when scape is laid back. Dorsum of head broadly convex in lateral view. ***Mesosoma*.** Promesonotum with dorsal profile slightly arched in lateral view, nearly flat; suture indistinct. Metanotum absent; metanotal groove distinct and strongly impressed; In lateral view, propodeum spineless; the dorsal face of propodeum straight, forming an obtuse angle with the declivity of propodeum; declivity nearly straight, with median portion slightly concave; anterodorsal corner forming an acute tooth behind metanotal groove in lateral view. ***Waist*.** Petiole longer than high with long peduncle (PTL 0.18, PTH 0.15) in lateral view; ventral margin of petiole slightly convex; petiolar node broader than long with anterodorsal and posterodorsal faces convex in dorsal view. In lateral view, combined profile of anterior face of node and peduncle convex distinctly. Declivity of the posterior face of petiole slightly steeper than anterior face. Postpetiole with lower node than petiole, both dorsa of petiolar and postpetiolar nodes roundly convex. ***Gaster*.** Oval, relatively short. ***Sculpture and hairs*.** In full-face view, head

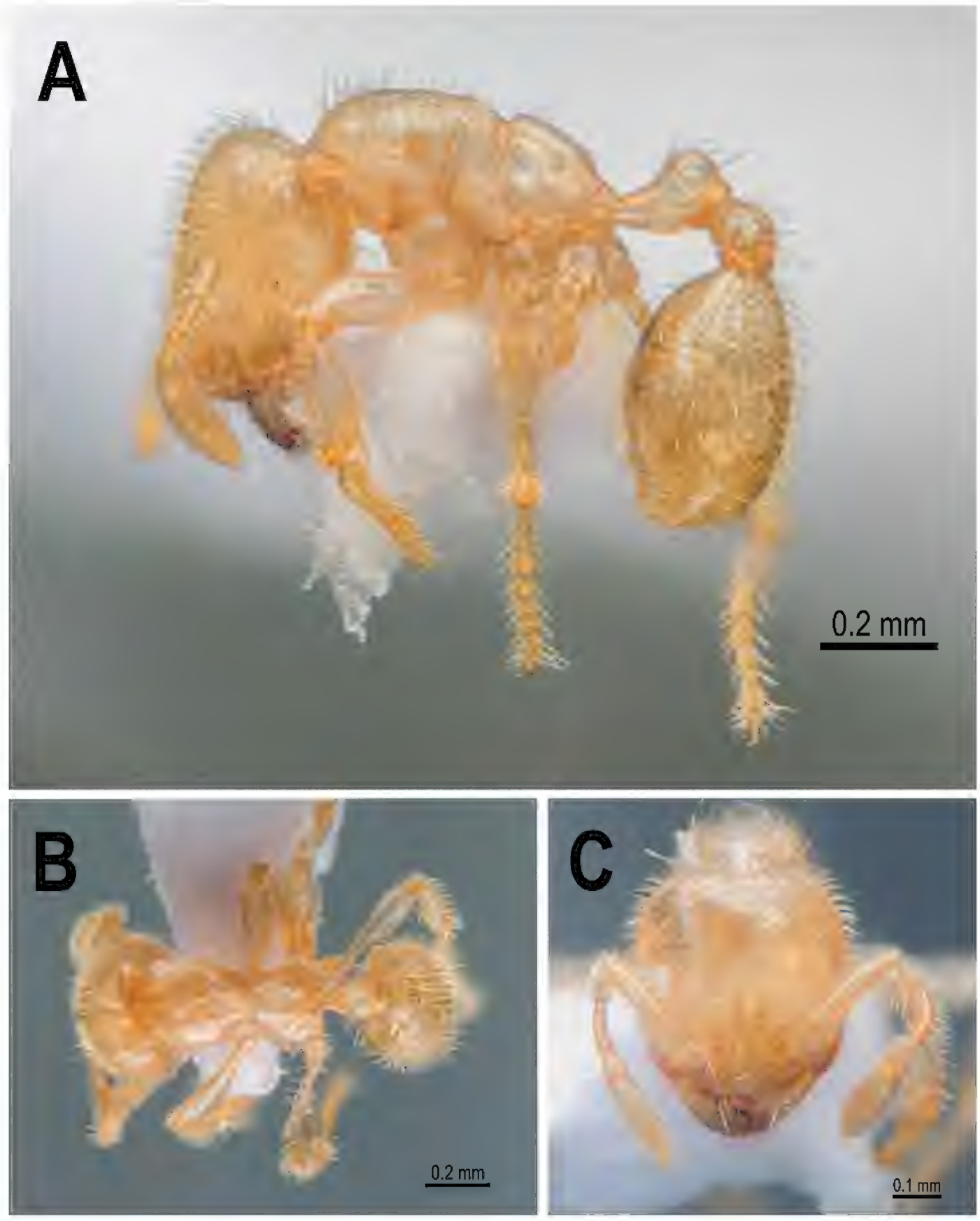

Figure 29. *Carebara laeviceps* Liu & Zhong, sp. nov. Paratype minor worker **A** body in lateral view **B** body in dorsal view **C** head in full-face view.

capsule, clypeus, and mandibles mostly smooth; only gena and frontal lobe with indistinct longitudinal rugulae; sculpture on mesosoma same as major workers. Gaster smooth and shiny. Whole head with abundant erect to suberect hairs; hairs on frons slightly sparser; scapes and lateral margin of mandibles with dense decumbent hairs. Dorsal and lateral faces of promesonotum with long erect hairs and short suberect hairs; propodeum with very sparse hairs. Hairs on waist and gaster like major worker. ***Color.*** Whole body yellowish white.

Etymology. The specific epithet *laeviceps* refers to the smooth and shiny head of the major workers.

Biology. Little known, the type material was collected in the grassland of Hanlin Village, Kaijiang City. The species nests underground and feeds on small invertebrates. Some major workers exhibit a swollen gaster, serving as a storage organ for reserves during foraging.

Remarks. *Carebara laeviceps* is most similar to *C. lusciosa*, *C. bouvardi* (Santschi, 1913) and *C. rectangulata* Bharti & Kumar, 2013, but can be easily

Figure 30. *Carebara laeviceps* Liu & Zhong, sp. nov. Minor worker under SEM. head in full-face view.

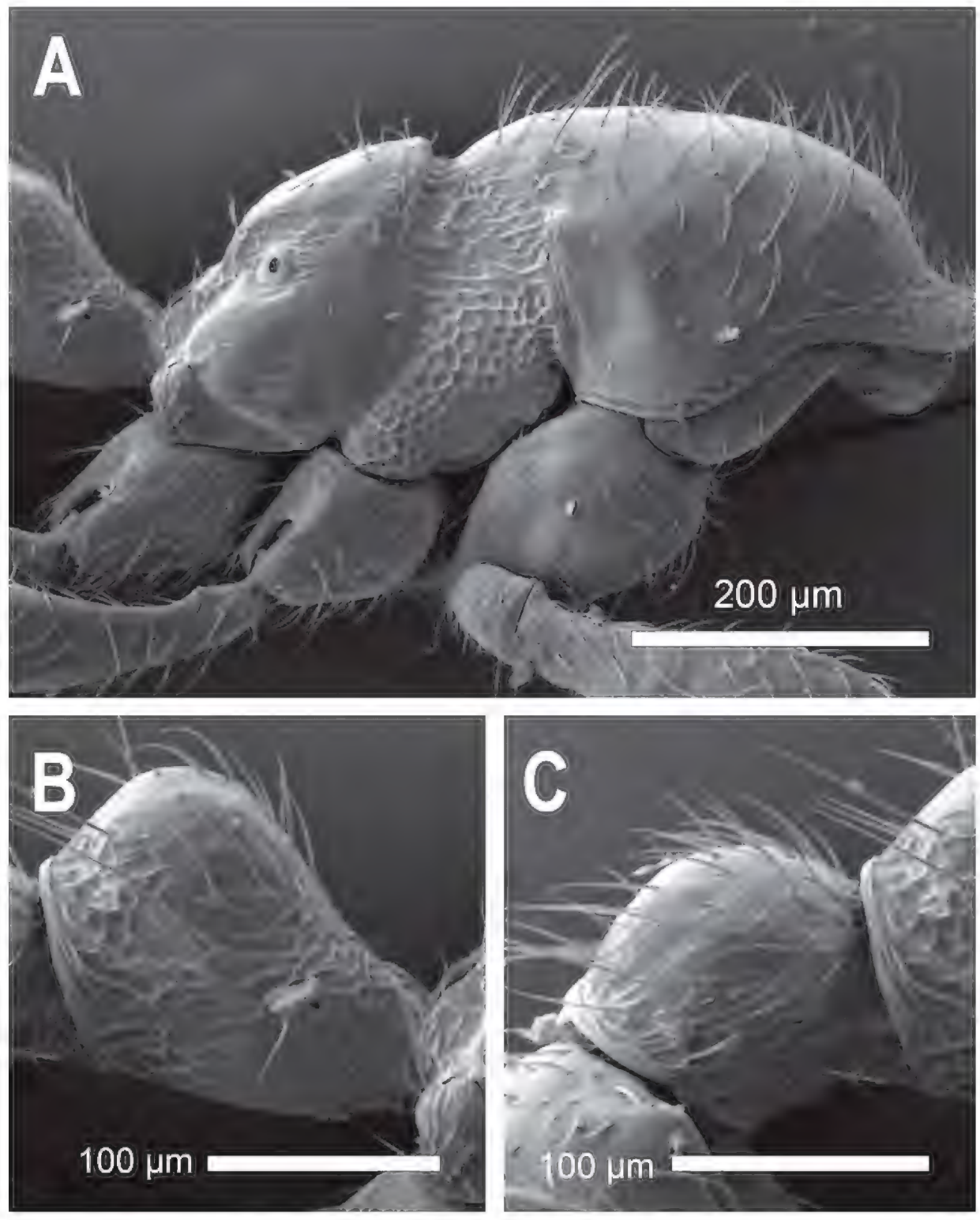

Figure 31. *Carebara laeviceps* Liu & Zhong, sp. nov. Minor worker under SEM **A** body in lateral view **B** petiole in lateral view **C** postpetiole in lateral view.

distinguished from these three species by combination of the following features: antenna 10-segemented (9-segmented in *C. lusciosa*, *C. bouvardi*, and *C. rectangulata*); posterior margin of head without a transverse carina in major worker (with a transverse carina in *C. rectangulata*); lateral profile of head in major worker parallel in full face view (subparallel in *C. lusciosa*); katepisternum finely rugose-reticulate in major worker (smooth in *C. lusciosa*, punctured in *C. rectangulata*); ventral face of petiole moderately convex (straight in *C. bouvardi* and *C. rectangulata*); distinctly larger with TL ~ 2.8 mm (*C. lusciosa*: 2 mm, *C. rectangulata*: 2.41 mm, *C. bouvardi*: ~ 2.4 mm).

Taxonomic checklist of *Carebara* species in China

A checklist of all known *Carebara* species in China is presented here based on Xu (2003), Zhou et al. (2006), and Terayama et al. (2012). The changes in taxonomic status, diagnostic features and distribution data of each species are provided. The checklist is arranged alphabetically.

C. acutispina (Xu, 2003)

Oligomyrmex acutispinus Xu, 2003: 315, figs 16–19 (s.w.) China (Yunnan). Indomalaya.
Carebara acutispina (Xu, 2003). Combination in *Carebara*: Guénard and Dunn 2012: 41.

Geographic distribution. China (type locality. Sichuan, Yunnan).

References. Xu (2003); Fontanilla et al. (2019); He et al. (2020); Liu et al. (2020); Hosoishi et al. (2022).

C. affinis (Jerdon, 1851)

Oecodoma affinis Jerdon, 1851: 110 (s.w.) India. Indomalaya.
Pheidole affinis (Jerdon, 1851). Combination in *Pheidole*: Smith 1858: 174.
Pheidologeton affnis (Jerdon, 1851). Combination in *Pheidologeton*: Roger 1863: 30.
Carebara affinis (Jerdon, 1851). Combination in *Carebara*: Fischer et al. 2014: 71.

Geographic distribution. Widespread in Australasia and Indomalaya region: Bangladesh, Borneo, China (Guangdong, Guangxi, Hainan, Hong Kong, Taiwan, Xizang, Yunnan), India (type locality), Indonesia, Laos, Malaysia, Myanmar, Nicobar Island, Philippines, Sri Lanka, Thailand, Australia, Papua New Guinea.

References. Zhou and Zheng (1997); Zhou (2001); Lin and Wu (2003); Zhou et al. (2006); Terayama (2009); Guénard and Dunn (2012); Liu et al. (2020).

C. altinodus (Xu, 2003)

Oligomyrmex altinodus Xu, 2003: 312, figs 5–8 (s.w.) China (Yunnan). Indomalaya.
Carebara altinodus (Xu, 2003). Combination in *Carebara*: Guénard and Dunn 2012: 41.

Geographic distribution. China (type locality. Hainan, Jiangxi, Xizang, Yunnan).

References. Xu (2003); Chen et al. (2011); Guénard and Dunn (2012); Liu (2012); Song et al. (2013); Liu et al. (2016); Lu and Chen (2016); Liu et al. (2017); Fontanilla et al. (2019); He et al. (2020); Lee et al. (2020); Zhang et al. (2022).

C. amia (Forel, 1913)

Solenopsis amia Forel, 1913: 191 (q.) China (Taiwan). Indomalaya.
Aneleus amia (Forel, 1913). Combination in *Aneleus*: Emery 1923: 60.
Oligomyrmex amia (Forel, 1913). Combination in *Oligomyrmex*: Ettershank 1966: 123.
Carebara amia (Forel, 1913). Combination in *Carebara*: Fernández 2004: 235.

Geographic distribution. China (type locality. Taiwan).

References. Lin and Wu (2003); Terayama (2009).

Remarks. This species only with queen caste described and not similar to any known species.

C. bihornata (Xu, 2003)

Oligomyrmex bihornatus Xu, 2003: 317, figs 24–27 (s.w.) China (Yunnan). Indomalaya.
Carebara bihornata (Xu, 2003). Combination in *Carebara*: Guénard and Dunn 2012: 41.

Geographic distribution. China (type locality. Yunnan).

References. Xu (2003); Guénard and Dunn (2012); Liu et al. (2020).

C. capreola (Wheeler, 1927)

Oligomyrmex (*Hendecatella*) *capreolus* Wheeler, 1927: 93, fig. 5 (s.w.m.) Vietnam. Indomalaya.
Carebara capreola (Wheeler, 1927). Combination in *Carebara*: Fernández 2004: 235.

Geographic distribution. China (Guangdong, Macao), Vietnam (type locality).

References. Xu (2003); Guénard and Dunn (2012).

C. capreola laeviceps (Wheeler, 1928)

Oligomyrmex (*Hendecatella*) *capreolus* subsp. *laeviceps* Wheeler, 1928: 24 (s.) China (Macao).
Carebara capreola laeviceps (Wheeler, 1928). Combination in *Carebara*: Guénard and Dunn 2012: 41.

Geographic distribution. China (type locality. Guangdong, Macao).

References. Wheeler (1930); Guénard and Dunn (2012).

***C. castanea* Smith, 1858**

Carebara castanea Smith, 1858: 178 (q.) China (Hong Kong). Indomalaya.

Geographic distribution. China (type locality. Hong Kong), Laos, Thailand.
References. Xu (1999); Guénard and Dunn (2012).

***C. curvispina* (Xu, 2003)**

Oligomyrmex curvispinus Xu, 2003: 313, figs 9–12 (s.w.) China (Yunnan). Indomalaya.
Carebara curvispina (Xu, 2003). Combination in *Carebara*: Guénard and Dunn 2012: 41.

Geographic distribution. China (type locality. Yunnan).
References. Xu (2003); Guénard and Dunn (2012).

***C. diversa* (Jerdon, 1851)**

Oecodoma diversa Jerdon, 1851: 109 (s.w.) India (Kerala). Indomalaya.
Pheidole diversa (Jerdon, 1851). Combination in *Pheidole*: Smith 1858: 174.
Pheidologeton diversa (Jerdon, 1851). Combination in *Pheidologeton*: Roger 1863: 30.
Carebara diversa (Jerdon, 1851). Combination in *Carebara*: Fischer et al. 2014: 71.

Geographic distribution. Widespread species, mainly in Indomalayan region: Bangladesh, Borneo, Cambodia, China (Fujian, Guangdong, Guangxi, Hainan, Hong Kong, Macao, Taiwan, Yunnan), Guinea, India (type locality), Indonesia, Japan, Laos, Malaysia, Myanmar, Philippines, Singapore, Sri Lanka, Thailand, Vietnam.
References. Wu and Wang (1995); Zhou and Zheng (1997); Zhou (2001); Lin and Wu (2003); Zhou et al. (2006); Terayama (2009); Guénard and Dunn (2012).

***C. diversa draco* (Santschi, 1920)**

Pheidologeton diversus st. *draco* Santschi, 1920: 163 (s.w.q.) Vietnam. Indomalaya.
Pheidologeton diversus draco Santschi, 1920. Subspecies of *Pheidologeton diversus*: Wheeler 1929: 44.
Carebara diversa draco (Santschi, 1920). Combination in *Carebara*: Fischer et al. 2014: 71.

Geographic distribution. China (Guangdong, Hainan), Vietnam (type locality).
References. Wheeler (1930); Zhou et al. (2006); Guénard and Dunn (2012).

***C. diversa laotina* (Santschi, 1920)**

Pheidologeton diversus var. *laotina* Santschi, 1920: 162 (s.w.q.) Laos, Vietnam. Indomalaya.
Pheidologeton diversus laotina Santschi, 1920. Subspecies of *Pheidologeton diversus*: Wheeler 1930: 68.

Pheidologeton laotina (Santschi, 1920). Status as species: Ettershank 1966: 119 (error).
Carebara diversa laotina (Santschi, 1920). Combination in *Carebara*: Fischer et al. 2014: 71.

Geographic distribution. Cambodia, China (Fujian, Guangdong, Hongkong, Macao), Laos (type locality), Vietnam (type locality).

References. Wheeler (1930); Zhou et al. (2006); Huang and Zhou (2007); Guénard and Dunn (2012).

C. hunanensis (Wu & Wang, 1995)

Oligomyrmex hunanensis Wu & Wang, 1995: 75, figs 90, 93 (s.w.) China (Hunan). Indomalaya.
Carebara hunanensis (Wu & Wang, 1995). Combination in *Carebara*: Guénard and Dunn 2012: 41.

Geographic distribution. China (type locality. Hong Kong, Hunan).

References. Xu (2003); Guénard and Dunn (2012).

C. jiangxiensis (Wu & Wang, 1995)

Oligomyrmex jiangxiensis Wu & Wang, 1995: 75, 194, figs 91, 94 (s.w.) China (Jiangxi). Indomalaya.
Carebara jiangxiensis (Wu & Wang, 1995). Combination in *Carebara*: Guénard and Dunn 2012: 41.

Geographic distribution. China (type locality. Guangdong, Jiangxi, Sichuan, Yunnan, Zhejiang).

References. Xu (2003); Zhao et al. (2009); Guénard and Dunn (2012); Staab et al. (2014); Huang et al. (2019); He et al. (2020).

C. latinoda (Zhou & Zheng, 1997)

Pheidologeton latinodus Zhou & Zheng, 1997: 165, figs 4–6 (s.w.) China (Guangxi). Indomalaya.
Carebara latinoda (Zhou & Zheng, 1997). Combination in *Carebara*: Fischer et al. 2014: 72.

Geographic distribution. China (type locality. Guangdong, Guangxi).

References. Zhou (2001); Zhou et al. (2006); Guénard and Dunn (2012).

C. lignata Westwood, 1840

Carebara lignata Westwood, 1840: 86, pl. 2, fig. 6 (q.) Indonesia (Java). Indomalaya.

Geographic distribution. Widespread in Indomalaya region: Bangladesh, China (Yunnan), India, Indonesia (type locality), Nepal.

References. Xu (1999); Guénard and Dunn (2012); Song et al. (2013); Lu et al. (2017).

C. lusciosa (Wheeler, 1928)

Oligomyrmex lusciosus Wheeler, 1928: 22 (s.w.) China (Guangdong). Indomalaya.
Carebara lusciosa (Wheeler, 1928). Combination in *Carebara*: Fernández 2004: 235.

Geographic distribution. China (type locality. Guangdong).

References. Xu (2003); Guénard and Dunn (2012).

C. melasolena (Zhou & Zheng, 1997)

Pheidologeton melasolenus Zhou & Zheng, 1997: 163, figs 1–3 (s.w.) China (Guangxi). Indomalaya.
Carebara melasolena (Zhou & Zheng, 1997). Combination in *Carebara*: Fischer et al. 2014: 72.

Geographic distribution. China (type locality. Chongqing, Guangxi, Hainan, Henan, Hong Kong, Hubei, Hunan, Jiangxi, Sichuan, Yunnan, Zhejiang).

References. Zhou (2001); Zhang and Zheng (2002); Zhou et al. (2006); Huang and Zhou (2007); Guénard and Dunn (2012); Staab et al. (2014); Liu et al. (2015); Liu et al. (2020).

Remarks. The status of this species is somewhat ambiguous, In Zhou and Zheng (1997) and Zhou et al. (2006), this species can be distinguished from *C. vespillo* (Wheeler, 1921) by the following characteristics: the coarse black line present in the median longitudinal groove of the head; postpetiolar node distinctly broader than long; and hairs sparser on the head and body. However, in Chen et al. (2021), *C. vespillo* was recorded with the presence of the black line. Accordingly, some former specimens of *C. vespillo* may have been misidentified as *C. melasolena* due to the presence of the black line. In Zhou and Zheng (1997), the authors pointed the postpetiolar node of *C. melasolena* is 1.5× broader than long, in Zhou et al. (2006) the node is 2× broader than long, maybe this ratio is a also an unstable morphological trait.

Above all, the features and separation of these two species needs further examination of the type specimens, it is possible that *C. melasolena* is a synonym of *C. vespillo*, but here we still list *Carebara melasolena* as a valid species based on former studies.

C. nanningensis (Li & Tang, 1986)

Pheidologeton nanningensis Li & Tang, 1986: 162 (s.w.) China (Guangxi). Indomalaya.
Carebara nanningensis (Li & Tang, 1986). Combination in *Carebara*: Fischer et al. 2014: 72.

Geographic distribution. China (type locality. Guangxi).

References. Zhou and Zheng (1997); Zhou et al. (2006); Guénard and Dunn (2012).

***C. obtusidenta* (Xu, 2003)**

Oligomyrmex obtusidentus Xu, 2003: 316, figs 20–23 (s.w.) China (Yunnan). Indomalaya.
Carebara obtusidenta (Xu, 2003). Combination in *Carebara*: Guénard and Dunn 2012: 41.

Geographic distribution. China (type locality. Hunan, Chongqing, Sichuan, Xizang, Yunnan), India.

References. Xu (2003); Huang (2005); Chen et al. (2011); Guénard and Dunn (2012); Liu (2012); Song et al. (2013); Fontanilla et al. (2019); Luo et al. (2019).

***C. oni* (Terayama, 1996)**

Oligomyrmex oni Terayama, 1996: 20, figs 38–43 (s.w.) Japan. Palearctic.
Carebara oni (Terayama, 1996). Combination in *Carebara*: Terayama 2009: 151.

Geographic distribution. China (Taiwan), Japan (type locality).

References. Lin and Wu (2003); Terayama (2009); Guénard and Dunn (2012); Terayama et al. (2012).

***C. pseudolusciosa* (Wu & Wang, 1995)**

Oligomyrmex pseudolusciosus Wu & Wang, 1995: 76, 195, figs 92, 95 (s.w.q.) China (Hubei, Anhui). Indomalaya.
Carebara pseudolusciosa (Wu & Wang, 1995). Combination in *Carebara*: Guénard and Dunn 2012: 41.

Geographic distribution. China (type locality. Anhui, Guangxi, Henan, Hubei).

References. Xu (2003); Guo (2006); Guénard and Dunn (2012); Lu (2013); Guo et al. (2015).

***C. polyphemus* (Wheeler, 1928)**

Oligomyrmex polyphemus Wheeler, 1928: 21 (s.) China (Guangdong). Indomalaya.
Carebara polyphemus (Wheeler, 1928). Combination in *Carebara*: Fernández 2004: 235.

Geographic distribution. China (type locality. Guangdong, Yunnan).

References. Xu (2003); Zhao et al. (2009); Guénard and Dunn (2012).

***C. qianliyan* Terayama, 2009**

Carebara qianliyan Terayama, 2009: 152, figs 230, 231 (s.w.) China (Taiwan). Indomalaya.

Geographic distribution. China (type locality. Taiwan).

References. Terayama (2009); Guénard and Dunn (2012); Terayama et al. (2012).

C. rectidorsa (Xu, 2003)

Oligomyrmex rectidorsus Xu, 2003: 319, figs 32–35 (s.w.) China (Yunnan). Palearctic.
Carebara rectidorsa (Xu, 2003). Combination in *Carebara*: Guénard and Dunn 2012: 41.

Geographic distribution. China (type locality. Chongqing, Hainan, Henan, Hubei, Hunan, Sichuan, Xizang, Yunnan), India.

References. Xu (2003); Huang (2005); Guo (2006); Guénard and Dunn (2012); Guo et al. (2015); Fontanilla et al. (2019); Huang et al. (2019); Luo et al. (2019); He et al. (2020); Lee et al. (2020).

C. reticapita **(Xu, 2003)**

Oligomyrmex reticapitus Xu, 2003: 319, figs 38–41 (s.w.) China (Yunnan). Palearctic.
Carebara reticapita (Xu, 2003). Combination in *Carebara*: Guénard and Dunn 2012: 41.

Geographic distribution. China (type locality. Guangxi, Hainan, Sichuan, Xizang, Yunnan).

References. Xu (2003); Chen et al. (2011); Guénard and Dunn (2012); Liu (2012); Chen et al. (2013); Song et al. (2013); Cheng et al. (2015); Liu et al. (2016); Liu et al. (2017); Fontanilla et al. (2019); He et al. (2020); Lee et al. (2020).

C. sakamotoi **Terayama et al., 2012**

Carebara sakamotoi Terayama et al., 2012: 2, figs 4–7 (s.w.) China (Taiwan). Indomalaya.

Geographic distribution. China (type locality. Taiwan).

References. Terayama et al. (2012).

C. sauteri **(Forel, 1912)**

Oligomyrmex sauteri Forel, 1912: 56 (s.) China (Taiwan, Zhejiang). Indomalaya.
Carebara sauteri (Forel, 1912). Combination in *Carebara*: Fernández 2004: 235.

Geographic distribution. China (type locality. Taiwan, Zhejiang), Japan.

References. Lin and Wu (2003); Xu (2003); Terayama (2009); Guénard and Dunn (2012); Terayama et al. (2012).

Remarks. In Wu and Wang's (1992) study, *C. hunanensis* was mistakenly identified as *C. sauteri* but was later corrected by Terayama (Wu and Wang 1995).

C. striata **(Xu, 2003)**

Oligomyrmex striatus Xu, 2003: 314, figs 13–15 (s.) China (Yunnan). Palearctic.
Carebara striata (Xu, 2003). Combination in *Carebara*: Fernández 2010: 202.

Geographic distribution. China (type locality. Sichuan, Yunnan).

References. Xu (2003); Guénard and Dunn (2012); He et al. (2020).

***C. taiponica* (Wheeler, 1928)**

Oligomyrmex silvestrii subsp. *taiponicus* Wheeler, 1928: 24 (s.) China (Hong Kong). Palearctic.
Oligomyrmex taiponicus Wheeler, 1928. Status as species: Bolton 1995: 300.
Carebara taiponica (Wheeler, 1928). Combination in *Carebara*: Fernández 2004: 235.

Geographic distribution. China (type locality. Hong Kong, Yunnan), Laos.

References. Xu (2003); Guénard and Dunn (2012).

***C. trechideros* (Zhou & Zheng, 1997)**

Pheidologeton trechideros Zhou & Zheng, 1997: 167, figs 7–9 (s.w.) China (Guangxi). Indomalaya.
Carebara trechideros (Zhou & Zheng, 1997). Combination in *Carebara*: Fischer et al. 2014: 72.

Geographic distribution. China (type locality. Guangdong, Guangxi, Hunan, Jiangxi, Sichuan, Yunnan), Thailand, Vietnam.

References. Zhou (2001); Zhou et al. (2006); Huang and Zhou (2007); Li et al. (2009); Zhao et al. 2009); Chen et al. (2012); Guénard and Dunn (2012); Song et al. (2013); Zhang et al. (2014); Fontanilla et al. (2019); Huang et al. (2019); Luo et al (2019).

***C. vespillo* (Wheeler, 1921)**

Pheidologeton vespillo Wheeler, 1921: 533 (s.w.) China (Zhejiang). Indomalaya.
Carebara vespillo (Wheeler, 1921). Combination in *Carebara*: Fischer et al. 2014: 72.

Geographic distribution. China (type locality. Guangxi, Henan, Hong Kong, Hunan, Jiangxi, Shandong, Zhejiang), Vietnam.

References. Wu and Wang (1992); Bolton (1995); Wu and Wang (1995); Zhou et al. (2006); Guénard and Dunn (2012); Lu (2013); Zhang et al. (2014); Cheng et al. (2015); Guo et al. (2015).

***C. wheeleri* (Ettershank, 1966)**

Oligomyrmex wheeleri Ettershank, 1966: 124. Replacement name for *Oligomyrmex silvestri* Wheeler, 1928: 23 (s.w.) China (Hong Kong). Palearctic.
Carebara wheeleri (Ettershank, 1966). Combination in *Carebara*: Fernández 2004: 235.

Geographic distribution. China (type locality Hong Kong, Yunnan).

References. Xu (2003); Guénard and Dunn (2012); Huang et al. (2019).

***C. yamatonis* (Terayama, 1996)**

Oligomyrmex yamatonis Terayama, 1996: 23, figs 48–51 (s.w.) Japan. Palearctic.
Carebara yamatonis (Terayama, 1996). Combination in *Carebara*: Terayama 2009: 151.

Geographic distribution. China (Hubei, Hunan), Japan (type locality).
References. Lin and Wu (2003); Huang (2005); Guénard and Dunn (2012).

***C. yanoi* (Forel, 1912)**

Pheidologeton yanoi Forel, 1912: 57 (w.q.) China (Taiwan). Indomalaya.
Carebara yanoi (Forel, 1912). Combination in *Carebara*: Fischer et al. 2014: 72.

Geographic distribution. China (type locality. Taiwan).
References. Wheeler (1929); Lin and Wu (2003); Zhou et al. (2006); Terayama (2009).

***C. zengchengensis* (Zhou et al., 2006)**

Pheidologeton zengchengensis Zhou et al., 2006: 871, figs 1, 2 (s.w.) China (Guangdong). Indomalaya.
Carebara zengchengensis (Zhou et al., 2006). Combination in *Carebara*: Fischer et al. 2014: 72.

Geographic distribution. China (type locality. Fujian, Guangdong, Macao).
References. Zhou et al. (2006); Zhang and Hou (2009); Zhao et al. (2009).

Discussion

In this study, a new *Carebara* species, *C. laeviceps* sp. nov. is described and the key and checklist of Chinese *Carebara* species are updated. Chinese *Carebara* species are predominantly small and subterranean, making the collection and identification quite challenging. Previous studies (Liu et al. 2020; Chen et al. 2021) have recorded several undescribed species. As future research advances, certain widely distributed Chinese species, such as *C. melasolena*, may reveal an extensive presence within the Indomalayan region. Furthermore, the Indo-China Peninsula may share certain widespread species with Yunnan and Guangxi provinces, such as *C. castanea* (Fig. 32).

The definition of the *Carebara* species groups is a complex question that requires large-scale research. Current studies, however, are mostly limited to a regional level. Unraveling the phylogenetic relationships among species groups in different faunas also demands a substantial amount of molecular data. Therefore, there is a need for a more comprehensive survey and taxonomic revision of *Carebara* species of the Old World.

A provisional definition of Chinese *Carebara* species groups is provided in this research, and some features of the *concinna-lignata* group have been updated. It is possible that these species might be divided into several distinct groups in future studies; for example, *C. altinodus*, *C. hunanensis*, *C. oni*, and

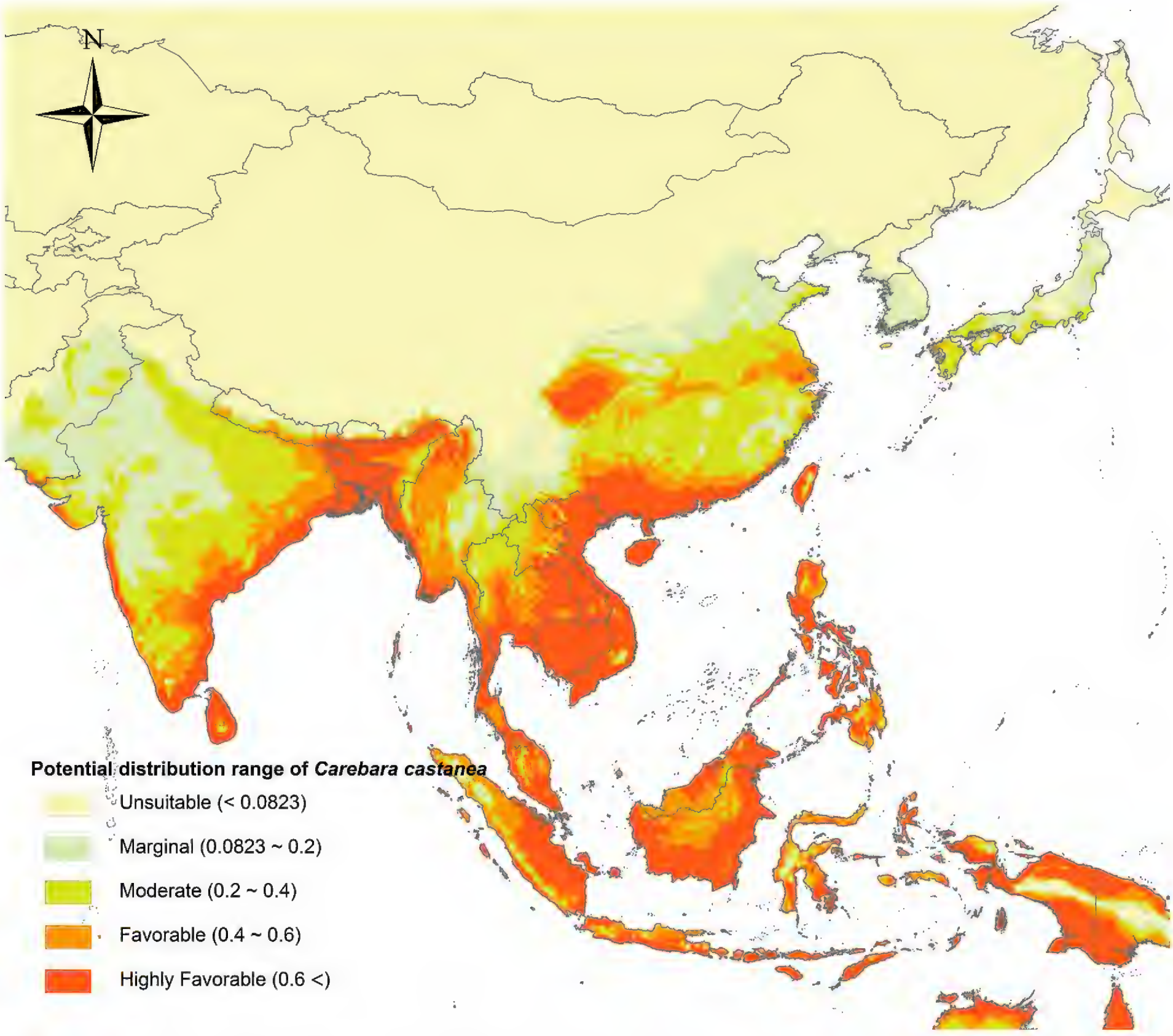

Figure 32. Potential distribution range of *C. castanea* under the current climate.

C. qianliyan could potentially form a single group due to various shared features, such as a massive mesosoma, the head capsule relatively short (CI > 90), large size (TL > 3.4 mm), and ocelli mostly present. Similarly, there may also be the *acutispina* species group but due to the lack of molecular data and to avoid making polyphyletic groups, we have maintained the classification proposed by Bharti and Kumar (2013).

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

Zhi-yu Liu: Illustration drawing, SEM photo shooting, drafting of the original manuscript; Ying Zhong: Illustration drawing, photography of holotype and paratype, writing and reviewing; Yu-yuan Huang: Supervision and reviewing; Hao Ran: Writing and reviewing; Fan Song: Supervision and reviewing.

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Data availability

All of the data that support the findings of this study are available in the main text.

References

Akbar SA, Bharti H (2017) A new species of the ant genus *Carebara* Westwood (Hymenoptera: Formicidae) from India. Journal of Entomological Research Society 19: 35–43. https://entomol.org/journal/index.php/JERS/article/view/1130

Azorsa F, Fisher BL (2018) Taxonomy of the ant genus *Carebara* Westwood (Formicidae, Myrmicinae) in the Malagasy Region. ZooKeys 767: 1–149. https://doi.org/10.3897/zookeys.767.21105

Baccaro FB, Feitosa RM, Fernández F, Fernandes IO, Izzo TJ, de Souza JLP, Solar R (2015) Guia Para os Gêneros de Formigas do Brasil. Editora INPA, Manaus, 388 pp. https://doi.org/10.5281/zenodo.32912

Bharti H, Akbar SA, Aldawood SA (2014) New additions to ant genus *Carebara* Westwood (Hymenoptera: Formicidae: Myrmicinae) from India. Acta Zoologica Academiae Scientiarum Hungaricae 60: 313–324. http://real.mtak.hu/24325/

Bharti H, Kumar R (2013) Six new species of *Carebara* Westwood (Hymenoptera: Formicidae) with restructuring of world species groups and a key to Indian species. Journal of Entomological Research Society 15(1): 47–67. https://doi.org/10.2478/vzoo-2013-0018

Bolton B (1987) A review of the Solenopsis genus-group and revision of Afrotropical Monomorium Mayr (Hymenoptera: Formicidae). Bulletin of the British Museum (Natural History). Entomology 54: 263–452. https://www.antwiki.org/wiki/images/3/3c/Bolton_1987.pdf

Bolton B (1994) Identification Guide to the ant Genera of the World. Harvard University Press, Cambridge, 222 pp.

Bolton B (1995) A new General Catalogue of the Ants of the World. Harvard University Press, Cambridge, 222 pp.

Bolton B (2023) An online catalogue of the ants of the World. https://antcat.org/catalog/429692?qq=carebara. [Accessed 29 November 2023]

Chen P, Su Y, Rao SS, Long YF, Du CH (2012) Study on the ant diversity in different *Illicium verum* stands. Xibu Linye Kexue 41(1): 60–68. https://doi.org/10.16473/j.cnki.xblykx1972.2012.01.001 [In Chinese]

Chen Y, Luo CW, Li HW, Liu YJ, Zheng HF, Yang FC (2013) Investigation of ant species and distribution on Wuliang Mountain. Henan Nongye Kexue 42(5): 118–122. https://doi.org/10.15933/j.cnki.1004-3268.2013.05.003 [In Chinese]

Chen Y, Luo CW, Li HW, Xu ZH, Liu YJ, Zhao SJ (2011) The investigation of soil ant resources on the West slope of Mt Ailao. Hubei Agricultural Sciences 50(7): 1356–1359. https://doi.org/10.14088/j.cnki.issn0439-8114.2011.07.001 [In Chinese]

Chen ZL, Yu ZM, Zhou SY (2021) Atlas of Ants in Huaping, Guangxi. Guangxi Normal University Press, 197 pp. [In Chinese]

Cheng D, Chen ZL, Zhou SY (2015) An analysis on the ant fauna of Jinzhongshan Nature Reserve in Guangxi, China. Journal of Guangxi Normal University: Natural Science Edition 33(3): 129–137. https://doi.org/10.16088/j.issn.1001-6600.2015.03.020 [In Chinese]

Emery C (1895) Die Gattung Dorylus Fab. und die systematische Eintheilung der Formiciden. Zoologische Jahrbucher. Abteilung fur Systematik, Geographie und Biologie der Tiere 8: 685–778.

Emery C (1913) La nervulation de l'aile antérieure des Formicides. Revue Suisse de Zoologie 21: 577–587.

Emery C (1914) Intorno alla classificazione dei Myrmicinae. Rendiconti delle Sessioni della Reale Accademia delle Scienze dell'Istituto di Bologna. Classe di Scienze Fisiche (n.s.) 18: 29–42.

Emery C (1924) Hymenoptera. Fam. Formicidae. Subfam. Myrmicinae. Genera Insectorum 174C: 207–397. [concl.]

Ettershank G (1966) A generic revision of the world Myrmicinae related to *Solenopsis* and *Pheidologeton* (Hymenoptera: Formicidae). Australian Journal of Zoology 14(1): 73–171. https://doi.org/10.1071/ZO9660073

Fernández F (2004) The American species of the myrmicine ant genus *Carebara* Westwood (Hymenoptera: Formicidae). Caldasia 26: 191–238.

Fernández F (2010) A new species of *Carebara* from the Philippines with notes and comments on the systematics of the *Carebara* genus group (Hymenoptera: Formicidae: Myrmicinae). Caldasia 32: 191–203.

Fischer G, Azorsa F, Fisher BL (2014) The ant genus *Carebara* Westwood (Hymenoptera, Formicidae): Synonymisation of *Pheidologeton* Mayr under *Carebara*, establishment and revision of the *C. polita* species group. ZooKeys 438: 57–112. https://doi.org/10.3897/zookeys.438.7922

Fischer G, Zorsa FH, Garcia F, Mikheyev A, Economo E (2015) Two new phragmotic ant species from Africa: Morphology and next-generation sequencing solve a caste association problem in the genus *Carebara* Westwood. ZooKeys 525: 77–105. https://doi.org/10.3897/zookeys.525.6057

Fontanilla AM, Nakamura A, Xu Z, Cao M, Kitching RL, Tang Y, Burwell CJ (2019) Taxonomic and functional ant diversity along tropical, subtropical, and subalpine elevational transects in southwest China. Insects 10(5): e128. https://doi.org/10.3390/insects10050128

Forel A (1893) Sur la classification de la famille des Formicides, avec remarques synonymiques. Annales de la Société Entomologique de Belgique 37: 161–167.

Forel A (1912) H. Sauter's Formosa-Ausbeute. Formicidae (Hym.) Entomologische Mitteilungen. Berlin-Dahlem 1: 45–81. https://doi.org/10.5962/bhl.part.25894

Forel A (1913) H. Sauter's Formosa-Ausbeute: Formicidae II. Archiv für Naturgeschichte 79(6): 183–202.

Guénard B, Dunn RR (2012) A checklist of the ants of China. Zootaxa 3358(1): 1–77. https://doi.org/10.11646/zootaxa.3558.1.1

Guo ZC (2006) Taxonomic Study on the Ant Fauna from Jigongshan and Funiushan in Henan Province. Guangxi Normal University. Master's thesis 91 pp. [In Chinese]

Guo ZC, Zhang RJ, Zhou SY (2015) Ant fauna of Formicidae in Jigong Mountain Nature Reserve in Henan Province, China. Guangxi Shifan Daxue Xuebao. Ziran Kexue Ban 33(1): 146–151. https://doi.org/10.16088/j.issn.1001-6600.2015.01.024 [In Chinese]

He Y, Xu Z, Xinmin Z, Zhao H, Zhongping X, Liu X, Liu N (2020) Ant species diversity of Western Daliangshan in Sichuan Province. Xinan Linye Daxue Xuebao 40(3): 104–115. https://doi.org/10.11929/j.swfu.201904047 [In Chinese]

Heterick BE (2021) A guide to the ants of Western Australia. Part I: Systematics. Records of the Western Australian Museum Supplement 86: 1–245. https://doi.org/10.18195/issn.0313-122x.86.2021.001-245

Hosoishi S, Yamane S, Sokh H (2022) Discovery of a new phragmotic species of the ant genus *Carebara* Westwood, 1840 (Hymenoptera, Formicidae) from Cambodia. Journal of Hymenoptera Research 91: 357–374. https://doi.org/10.3897/jhr.91.82490

Huang JH (2005) Hunan Ants (Hymenoptera) and the classification of flora. Southwest Agricultural University. PhD Thesis, Chongqing, 247 pp. https://d.wanfangdata.com.cn/thesis/Y733020 [In Chinese]

Huang JH, Zhou SY (2007) Checklist of Family Formicidae of China. Myrmicinae (Part III). (Insecta; Hymenoptera). Guangxi Shifan Daxue Xuebao. Ziran Kexue Ban 25(3): 88–96. [In Chinese]

Huang Z, Xu ZH, Liu X, Li LM, Wang YL, Shi SH, Shi Y, Chen ZF (2019) Ant species diversity in northeastern Yunnan. Shengtaixue Zazhi 38(12): 3697–3705. https://doi.org/10.13292/j.1000-4890.201912.027 [In Chinese]

Jerdon TC (1851) A catalogue of the species of ants found in Southern India. Madras Journal of Literature and Science 17: 103–127.

Kusnezov N (1964) Zoogeografía de las hormigas en Sudamérica. Acta Zoológica Lilloana 19: 25–186.

Lee R, Wang C, Guenard B (2020) The ecological implications of rubber-based agroforest: Insect conservation and invasion control. Journal of Applied Ecology 57(8): 1605–1618. https://doi.org/10.1111/1365-2664.13642

Li Q, Chen Y, Wang S, Zheng Y, Zhu Y, Wang S (2009) Diversity of ants in subtropical evergreen broadleaved forest in Pu'er City. Yunnan. Shengwu Duoyangxing 17(3): 233–239. https://doi.org/10.3724/SP.J.1003.2009.08035 [In Chinese]

Li S, Tang J (1986) The ant genus *Pheidologeton* of Guangxi and the description of a new species (Hymenoptera: Formicidae). Journal of Zhejiang Agricultural University 12(2): 160–165. [In Chinese]

Lin CC, Wu WJ (2003) The ant fauna of Taiwan (Hymenoptera: Formicidae), with keys to subfamilies and genera. Guoli Taiwan Bowuguan Niankan 46: 5–69. [In Chinese]

Liu C, Dudley KL, Xu Z, Economo EP (2017) Mountain metacommunities: Climate and spatial connectivity shape ant diversity in a complex landscape. Ecography 41(1): 101–112. https://doi.org/10.1111/ecog.03067

Liu C, Fischer G, Hita GF, Yamane S, Liu Q, Peng YQ, Economo EP, Guénard B, Pierce NE (2020) Ants of the Hengduan Mountains: a new altitudinal survey and updated checklist for Yunnan Province highlight an understudied insect biodiversity hotspot. ZooKeys 978: 1–171. https://doi.org/10.3897/zookeys.978.55767

Liu C, Guénard B, Hita Garcia F, Yamane S, Blanchard B, Yang DR, Economo E (2015) New records of ant species from Yunnan, China. ZooKeys 477: 17–78. https://doi.org/10.3897/zookeys.477.8775

Liu X (2012) Taxonomy, diversity and spatial distribution characters of the ant family Formicidae (Insecta: Hymenoptera) in southeastern Tibet. PhD Thesis, Beijing Forestry University, 139 pp. https://d.wanfangdata.com.cn/thesis/Y2193018 [In Chinese]

Liu X, Xu Z, Yu N, Zhang C (2016) Distribution patterns of ant species (Hymenoptera: Formicidae) in Galongla Mountains and Medog Valley of Southeastern Tibet. Linye Kexue 52(11): 88–95. https://doi.org/10.11707/j.1001-7488.20161111 [In Chinese]

Lu C (2013) The Ant Fauna in DamingShan National Nature Reserve of Guangxi. Master's Thesis Guangxi Normal University, 83 pp. [In Chinese]

Lu Z, Chen Y (2016) Effects of habitat on ant functional groups: A case study of Luchun County, Yunnan Province, China. Chinese Journal of Eco-Agriculture 24(5): 801–810. https://www.cabdirect.org/cabdirect/abstract/20163249611

Lu Z, Li K, Zhang N, Chen Y (2017) Diversity and indicator species of leaf-litter ants in Eucalyptus grandis plantations and secondary natural forests. Forest Research 29(4): 576–580. https://www.cabdirect.org/cabdirect/abstract/20163399369

Luo C, Xu Z, Zhu H, Yuan D, Qi B, Ran M (2019) Altitudinal gradient of ant species diversity of Wanglang Nature reserve and adjacent area in Sichuan Province. Journal of Fujian Agriculture and Forestry University 48(4): 485–492. https://doi.org/10.13323/j.cnki.j.fafu(nat.sci.).2019.04.013 [In Chinese]

Moffett M (1988) Foraging dynamics in the group-hunting myrmicine ant, *Pheidologeton diversus*. Journal of Insect Behavior 1(3): 309–331. https://doi.org/10.1007/BF01054528

Sharaf MR, Aldawood AS (2013) The ant genus *Carebara* Westwood in the Arabian Peninsula (Hymenoptera, Formicidae). ZooKeys 357: 67–83. https://doi.org/10.3897/zookeys.357.5946

Smith F (1858) Catalogue of Hymenopterous Insects in the Collection of the British Museum. Part VI. Formicidae. British Museum, London, 216 pp.

Song Y, Xu Z, Li C, Zhang N, Zhang L, Jiang H, Mo F (2013) An analysis on the ant fauna of the Nangun river nature reserve in Yunnan, China. Forest Research 26(6): 773–780. https://doi.org/10.16473/j.cnki.xblykx1972.2014.05.006 [In Chinese]

Staab M, Schuldt A, Assmann T, Bruelheide H, Klein M (2014) Ant community structure during forest succession in a subtropical forest in South-East China. Acta Oecologica 61: 32–40. https://doi.org/10.1016/j.actao.2014.10.003

Terayam M (1996) Taxonomic studies on the Japanese Formicidae, part 2. Seven genera of Ponerinae, Cerapachyinae and Myrmicinae. Nature & Human Activities 1: 9–32.

Terayama M (2009) A synopsis of the family Formicidae of Taiwan (Insecta: Hymenoptera). Research Bulletin of Kanto Gakuen University. Liberal Arts 17: 81–266.

Ward PS, Brady SG, Fisher BL, Schultz TR (2015) The evolution of myrmicine ants: phylogeny and biogeography of a hyperdiverse ant clade (Hymenoptera: Formicidae). Systematic Entomology 40(1): 61–81. https://doi.org/10.1111/syen.12090

Wheeler WM (1910) Ants: Their Structure, Development and Behavior. Columbia University Press, New York, 663 pp. https://doi.org/10.5962/bhl.title.1937

Wheeler WM (1921) Chinese ants. Bulletin of the Museum of Comparative Zoology 64: 529–547.

Wheeler WM (1922) Ants of the American Museum Congo Expedition. Bulletin of the American Museum of Natural History, New York, 1139 pp. http://hdl.handle.net/2246/932

Wheeler WM (1927) Ants collected by Professor F. Silvestri in Indochina. Bollettino del Laboratorio di Zoologia Generale e Agraria della Reale Scuola Superiore d'Agricoltura. Portici 20: 83–106.

Wheeler WM (1928) Ants collected by Professor F. Silvestri in China. Bollettino del Laboratorio di Zoologia Generale e Agraria della Reale Scuola Superiore d'Agricoltura. Portici 22: 3–38.

Wheeler WM (1929) Ants collected by Professor F. Silvestri in Formosa, the Malay Peninsula and the Philippines. Bollettino del Laboratorio di Zoologia Generale e Agraria della Reale Scuola Superiored'Agricoltura. Portici 24: 27–64.

Wheeler WM (1930) A list of the known Chinese ants. Peking Natural History Bulletin 5: 53–81. http://antbase.org/ants/publications/3417/3417.pdf

Wu J, Wang C (1992) Hymenoptera: Formicidae. In: Peng J, Liu Y (Eds) Iconography of Forest Insects in Hunan, China. Hunan Scientific and Technical Publishing House, Hunan, 1301–1320. [1473 pp] [In Chinese]

Wu J, Wang C (1995) The Ants of China. China Forestry Publishing House, Beijing, 214 pp. [In Chinese]

Xu Z (1999) Systematic studies on the ant genera of *Carebara*, *Rhopalomastix* and *Kartidris* in China (Hymenoptera: Formicidae: Myrmicinae). Acta Biologica Plateau Sinica 14: 129–136. http://antbase.org/ants/publications/8423/8423.pdf

Xu ZH (2003) A systematic study on Chinese species of the ant genus *Oligomyrmex* Mayr (Hymenoptera: Formicidae). Acta Zootaxonomica Sinica 28: 310–322.

Zhang RJ, Liang LW, Zhou SY (2014) An analysis on the ant fauna of Nonggang Nature Reserve in Guangxi, China. Guangxi Shifan Daxue Xuebao. Ziran Kexue Ban 32(3): 86–93. https://doi.org/10.16088/j.issn.1001-6600.2014.03.039 [In Chinese]

Zhang W, Zheng Z (2002) Studies of ant (Hymenoptera: Formicidae) fauna in Sichuan Province. Entomotaxonomia 24(3): 216–222. [In Chinese]

Zhang X, Hou YM (2009) Five new record genus and thirty one new records species of ants (Hymenoptera; Formicidae) in Fujian Province. Journal of Fujian Agriculture and Forestry University 38(5): 479–484.

Zhang X, Lu Z, Zhang N, Chen Y (2022) Data of ant community compositions and functional traits responding to land-use change at the local scale. Biodiversity Data Journal 10: e85119. https://doi.org/10.3897/BDJ.10.e85119

Zhao S, Jia FL, Liang GQ, Ke YL, Tian WJ (2009) Ants and their distribution in Guangdong Province, China. Huanjing Kunchong Xuebao 31(2): 156–161. https://doi.org/10.3969/j.issn.1674-0858.2009.02.010 [In Chinese]

Zhou S (2001) Ants of Guangxi. Guilin, China: Guangxi Normal University Press, 255 pp. [In Chinese]

Zhou S, Zhao S, Jia F (2006) A taxonomic study on the ant genus *Pheidologeton* Mayr (Hymenoptera, Formicidae, Myrmicinae) from China. Acta Zootaxonomica Sinica 31: 870–873. http://www.cqvip.com/qk/90158x/200604/23155773.html

Zhou S, Zheng Z (1997) A taxonomic study on the ant genus *Pheidologeton* Mayr in Guangxi (Hymenoptera: Formicidae). Zoological Research 18: 163–170. http://antbase.org/ants/publications/8443/8443.pdf [In Chinese]